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The Institute is requesting from industry and persons interested in agriculture, financial assistance totalling £10,000 per year during each of the next four years. With this aid it is proposed to extend the Institute's activities to emphasise the importance of scientific agriculture to Australia and help in solving the problems of the financial stability of this country.

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GUIDE TO AUTHORS.

The Journal aims to publish material of interest to Agricultural Scientists, contributed by authors working in agricultural or related fields; authors need not be members of the Institute.

Contributions are of three types, namely: "Articles", "Technical Papers" and "Technical Notes". For information about the size and form of each type of contribution, see page 2 of the March, 1955, issue of the Journal.

Manuscripts should be double spaced and should be submitted in duplicate, as part of the delay in referring is then avoided.

For more detailed information concerning the preparation and lay-out of scientific papers, authors are referred to the C.S.I.R.O. publication "Guide to Authors" and to an article entitled "The Preparation and Editing of Technical Papers" by N. S. Noble, published in the Australian Library Journal, April, 1954. The policy laid down in these publications is also largely followed by this Journal.

In addition to the contributions described above, the Journal is pleased to publish "Letters", "News Items", "Talks" and "Personal Notes" which have been received from, or which are of interest to, members of the Institute.

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THE INSTITUTE — 1953/1956

During the past four years there has been a remarkable increase in the activity of the Institute. In this period it has accepted its responsibilities to the community as a professional organisation, and made an effort to correct deficiencies in agriculture which, in its opinion, needed attention in the public interest.

The increased enrolments of students in agricultural science at Australian Universities is mainly due to such an effort, and provides an example of just how effective the Institute can be if it chooses to pursue all of its objects as stated in the Memorandum of Association.

It could not have done this effectively without the establishment of a Central Office, equipped in accordance with modern standards for efficiency and convenience, and a full-time Executive Officer to plan, co-ordinate and make the most effective use of the mobilised talent of Institute members.

The establishment of the Central Office has been made possible by financial aid from the Commonwealth Extension Services Grant, for which the Institute is grateful. There is no doubt that it has carried out effectively the one task that was expected of it when such a grant was made.

For the first time the Institute has taken deliberate action to inform the public of its activities, and the function of the agricultural scientist in the community.

Assistance from industries associated with the welfare of agriculture has now been sought for extending the Institute's public activities, and there has been a remarkable response. These companies apparently appreciate the part played by agricultural science in improving Australian agriculture, and are obviously willing to assist.

The Institute is now becoming recognized as an active professional organisation prepared to assume a degree of public responsibility in matters with which it should be concerned. It is also becoming accepted as a body from which can be expected effective action.

It will continue to undertake these public responsibilities effectively and assume even greater influence *only if members are prepared to accept their individual burden in the initiation of such projects.* The immediate gain to individual members may not be obvious, but in time such a policy will provide its reward.

ARTICLES

THE MEASUREMENT OF NATURAL EVAPORATION

By I. C. McILROY

Introduction

Two good general reviews of evaporation have recently appeared (Deacon, Priestley & Swinbank, 1956; Penman, 1956). This paper is therefore limited to a discussion of the methods available for its measurement.

These fall into three groups, based respectively on determining

(a) The water balance of the evaporating system,
(b) The upward flow of water vapour in the air layers near the ground,
(c) The energy available for the conversion of liquid water into vapour.

Although historically the importance of (c) was recognized as early as Aristotle, approaches (a) and (b), not very clearly separated, were the first to be used. For instance, there were many attempts to correlate water loss from standard surfaces such as water tanks with the 'evaporative power' of the atmosphere, expressed as some simple function of the more obvious variables, e.g., windspeed and humidity or vapour pressure. It was hoped that measurement of the latter quantities would then suffice for determining the evaporation from other surfaces of greater interest, in particular from such larger bodies of water as lakes and dams.

More recently, however, the importance of the differences between various evaporating systems has been increasingly realised. Readings of standard evaporimeters are now seen to be only a substitute, and often an extremely unreliable one, for the determination of natural evaporation from measurements of the actual processes involved.

Empirical formulae for evaporative power, particularly when combined with an energy balance approach, can still be useful where only limited data is available, but their limitations must be realised. Meanwhile the emphasis is shifting towards either type (a) methods applied to truly representative soil blocks or water bodies, or type (b) and (c) methods with direct instrumental determination of the important quantities concerned.

(a) Water Balance Methods

All the group (a) methods make use of some form of the hydrologic equation

$$P = E + O + D + \Delta W \qquad (1)$$

where P is precipitation, E evaporation, O surface runoff, D subsurface drainage and ΔW is the change in water content of the block of soil or other medium being considered. By measuring or eliminating all but one of these variables, the remaining one can be found.

A well-known application of this principle on a large scale is the catchment area balance sheet, where over long periods, or from one state of wetness or dryness to the next similar one, ΔW can be neglected, while P and O are generally comparatively easily measured, and D small enough to require only estimation.

Where lakes and reservoirs are known to be free from seepage D can be neglected, stream gauging will give O, and ΔW can be obtained volumetrically.

On a smaller scale, by enclosing a block of soil or choosing one naturally suitable, O and D can be eliminated or readily determined, ΔW can be obtained

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by periodical weighing of the soil plus container, or by local determinations of soil moisture content.

The simplest case of all is that of a tank of water, for which $E = P - \Delta W$, with ΔW obtainable from changes in level.

(i) *Free Water Surfaces-Standard Evaporimeters*

Because of their ease of operation standardised tanks of water have become the most widely adopted evaporation instruments throughout the world. However their readings have been shown to depend considerably on their size and construction, and, to a smaller extent, on their exposure (Rohwer 1934). The disturbing effect of the rim of the tank on air flow appears rather important (Penman 1948a). Bonython (1950) reports a difference of 15 per cent. in evaporation rate due to a change of level of 2 inches in the Australian standard pan.

A summary of earlier workers' data by Penman (loc cit) shows a decrease in rate of evaporation per unit area from surfaces of increasing size. This is to be expected from the progressive moistening of the air as it moves over the surface. Other factors such as the reduced importance of edge effects will also play a part.

A great deal of effort has gone into the search for a satisfactory pan coefficient, i.e., a multiplying factor to be applied to an evaporimeter pan reading to give the appropriate value for a large water surface undergoing the same weather conditions. Much of this work has been summarised by Kohler (1952) in the Lake Hefner report.

He shows a large variation in both annual and monthly coefficients relating various sized lakes and dams to several types of American pan. For instance, there was in an extreme case a monthly range of from 1.6 in November 1950 to 0.2 in February 1951.

Not all of this variation is due to the pans themselves. The evaporation rate from a large water surface is itself affected by such local characteristics as the depth and turbidity of the water, and also by its rate of mixing. These together determine the vertical extent of water which shares in the incoming energy supply during the day (or the summer) and which supplies energy to the surface at night (or in winter). In other words they determine the effective heat storage capacity of the lake and hence the degree of 'lagging' of its daily and annual cycle of temperature and vapour pressure.

Thus the peak temperature and vapour pressure of a lake of sufficient *effective* depth will occur appreciably later than that of the surrounding countryside, or of a nearby pan. Its peak rate of evaporation will do likewise. An admittedly extreme example of this is afforded by the contrast between Lake Superior and a smaller neighbouring lake. The peak evaporation of the former occurs in winter, six months behind that of the latter, according to computations by Wisler and Brater (1949).

Such phase differences, combined with appreciable amplitude differences, put out of the question a universal pan coefficient. They also make it dangerous to apply existing empirical coefficients outside the ranges for which they have been determined.

Although tank readings may have some use for indicating rates of evaporation from small thoroughly moist soil or grass surfaces they again become inapplicable as the soil dries out. Under arid conditions natural evaporation may be virtually zero while a water tank is evaporating freely.

The same is true of other simple devices due to de la Rue, Lamont, Piche, Wild and others, all of which substitute a standard surface for the natural one under consideration. For example, the Piche atmometer consists essentially of a piece of blotting-paper clamped across the mouth of a water-filled glass tube. It is often supposed to simulate the behaviour of transpiring plants. De Vries and Venema (1954) have shown that it

gives little more than an indication of the water demand on a single leaf having the same exposure as the paper disc. When compared with the demand on the vegetation as a whole the atmometer overestimates the effect of wind and underestimates that of radiation. In addition it ignores the effect of biological control of transpiration.

Many attempts have been made to find satisfactory correlations between evaporimeter readings and water loss from natural surfaces.

West and Perkman (1953), working in an irrigated citrus orchard at Griffith, N.S.W., found an empirical relation between decrease of soil moisture content and water loss from a black pan evaporimeter. Certain factors would need re-determination for any other combination of soil, crop and evaporimeter exposure. However the subsequent requirements of the method are simple, and an accuracy adequate for irrigation control appears possible.

(ii) Lysimeters

In the case of evaporation from soil, a closer approach to natural conditions is obtained by the use of lysimeters or drain-gauges. These consist of blocks of the appropriate soil and vegetation, set in the ground flush with, but more or less isolated from, their surroundings.

In order to obtain better experimental control the trend is towards complete isolation, but where possible the container is built in situ, around an undisturbed soil block—the so-called monolithic construction. Where this cannot be done the container should be filled a layer at a time, each layer coming from the corresponding level in the natural profile and restored to its original density.

Runoff is usually prevented, but may be collected and measured. So also is any percolate draining through the soil. Precipitation is measured in the usual way. By the use of elaborate weighing gear the water loss from such units can be determined to a high degree of accuracy, with sensitivities up to the equivalent of 0.01 inches of surface water.

To ensure representative behaviour a number of precautions must be taken. In particular containers should be large (at least $1m^3$ in volume), to reduce the importance of boundary effects and to avoid restricting root development. With small plants such as grasses this also ensures a typical community. To ensure proper drainage the bottom of an isolated soil-column will often require the artificial application of a moisture suction equivalent to that present at the same depth in the natural soil (Colman 1946).

If lysimeter readings are to have more than a purely local significance the influence of the surroundings must be reduced. To do this each lysimeter should have a "guard-ring" area around it maintained under the same crop and moisture conditions. How large this should be will depend on the degree of contrast with the surroundings. For a moist area surrounded by desert Thornthwaite (1954) has suggested that ten acres may not be enough.

To obtain the same effective exposure for *adjacent* lysimeters Deacon, Priestley and Swinbank (1956) have indicated that the "guard-ring" radius may have to be about ten times the lysimeter separation.

In spite of the cost and effort involved a number of such installations now exist. The most elaborate of these, each comprising a group of very large weighed lysimeters, are at Coshocton, U.S.A. (Harrold and Dreibelbis, 1951); Wageningen, Holland (Makkink 1953), and Valdai, U.S.S.R. (Popov 1952).

In Australia a smaller weighed set has been in operation for several years at the Irrigation Research Station at Griffith, N.S.W. (Arthur 1955), and one comparable in scope with those mentioned above is now under construction in the Division of Meteorological Physics, C.S.I.R.O., Aspendale, Victoria, (McIlroy 1956).

A small scale version of the lysimeter method has been shown by Pasquill (1949, 1950) to be useful over short periods with moist shallow rooted pastures.

(*iii*) *Potential Evapo-Transpirometers*

These are really a specialised form of lysimeter, limited to use with soils kept permanently moist. They are therefore unrepresentative of most Australian agricultural practice. This applies even to irrigated areas, where the water supply is usually far too infrequent to maintain such conditions.

Instrumentally they can be very simple. A standardised version, with some particular crop, e.g., an irrigation pasture mixture, would for many purposes be a definite improvement on the tank evaporimeter.

The basic requirements are a simple container, such as a large oil-drum (cf. Gilbert 1954), with provision for irrigation and for collecting and measuring percolate. In operation a measured amount of water, always sufficient to bring about some drainage, is applied at regular intervals. With the soil never far from field capacity, ΔW in equation (1) can generally be neglected by comparison with E, particularly over long periods. The water consumption is then obtained as the difference between the amount of water supplied and that collected as percolate.

The concept of potential evapo-transpiration itself (Thornthwaite 1948, 1954) will not be discussed here, beyond remarking that whereas it was originally supposed to be a purely climatic parameter, independent of the nature of the vegetation concerned, considerable evidence to the contrary has now emerged (e.g., Mather 1954).

(*iv*) *The Soil Moisture Profile*

A further method of arriving at ΔW in equation (1) is by sampling the changes in soil moisture content throughout the volume of soil considered. The evaporation from open soil areas of any size can be determined in this way, provided no water table is present and deep percolation is absent or measurable. The techniques involved were recently reviewed by Olson and Hoover (1954).

Because of spatial variations extensive replication of measurements is generally necessary. The requirements for this vary widely, but it is rarely possible to do with less than about half a dozen measurements at each of four or more levels. With deep-rooted plants the lowest of these may have to be six feet or more down.

The most fundamental of the methods employed is actual removal of soil samples, which are weighed, dried and reweighed. Although it can be quite accurate this procedure is very time-consuming, even with modern balances and simple techniques for drying the samples, such as burning alcohol directly on them. Over any lengthy period the experimental plot must be rather large to survive the destructive effect of continuous sampling.

The variation of electrical resistance or capacitance, either of the soil itself or, more commonly, of porous blocks buried in the soil, has been used extensively. The electrical properties of such blocks are dependent on their moisture content. The latter is a function of soil moisture tension, provided satisfactory contact is maintained between block and soil.

The range of coverage of any one type of block is limited, although it is claimed that a composite block, of fibre-glass and gypsum, is usable from 0.5 to 30 atmospheres tension. In spite of certain disabilities, including lack of long-term stability, liability to hysteresis effects and some dependence on temperature and on the salinity of the soil water, the method has been used with considerable success by a number of workers, e.g., Butler and Prescott (1955), Slatyer (1955). A comprehensive discussion of gypsum block techniques is given by Aitchison and Butler (1951) and Aitchison, Butler and Gurr (1951).

A widely used method suitable for the moister end of the range, with tensions

up to 0.8 atmosphere, is the direct measurement of moisture tension. The tensiometers used consist of porous bulbs or plates embedded in the soil and connected by tubing to a suitable manometer. They are filled with water which moves into or out of the bulb, varying the pressure within, depending on the moisture suction of the surrounding soil. These instruments are comparatively simple to operate, but also require good contact, and are subject to large temperature effects, as well as being very susceptible to air leakage.

Freedom from most of the above disadvantages can be achieved by measurement of the thermal properties of the soil, e.g., by determining the rate of temperature rise when heat is supplied at a constant rate nearby (de Vries 1952; Momin 1947; Shaw and Baver 1939a and b). As with moisture tension devices a calibration in terms of moisture content is necessary for each soil. The probes used are in general rather delicate, and again dependent on good contact with their surroundings. Van Duin and de Vries (1954) report good agreement between evaporation rates obtained from such elements and from weighed lysimeters at Wageningen.

A recent and promising development is the neutron scattering method (see for instance Belcher, Cuykendall and Sack 1950; Holmes 1956). Atomic particles such as neutrons are slowed down by collisions with surrounding nuclei. Of those normally present in soil the hydrogen nucleus is very much the best "moderator" for neutrons. Thus a source of fast neutrons within the soil will become surrounded by a cloud of slower scattered neutrons, the density of which depends on the local concentration of hydrogen. This in practice means the soil water content.

A portable probe comprising a fast neutron source and a slow neutron detector is therefore inserted into the soil, via a suitable tube. The counting rate of the detector is determined electronically, and is found to be a measure of the water contained in a volume of about a cubic foot surrounding the probe. There are no contact, salinity or hysteresis problems, and only a small temperature effect. The accuracy claimed is of the order of 1 per cent., about the same as for thermal conductivity methods.

(b) Vapour Flow Methods

There are several approaches to finding the upward flow of water vapour into the atmosphere.

(*i*) *The Dalton Equation*

Empirical formulae have formed the basis of the oldest known systems of determining evaporation, and have been consistently pursued for over a century. Although other types of expression have been proposed (e.g., Bigelow 1907, 1908, 1910), the form usually adopted is that named after the pioneer of modern evaporation studies, John Dalton.

The so-called Dalton equation (never actually used by Dalton himself, although his experiments laid the groundwork for it) is

$$E = a\ (1 + bu)\ (e_s - e_a) \qquad (2)$$

where E is now a rate rather than a quantity of evaporation, a and b are empirical constants, u is the windspeed at some chosen height and e_s, e_a are the vapour pressures at the surface and in the bulk air respectively.

Almost all of the work done in this connection has been on evaporation from water surfaces. This permits e_s to be taken as ϵ_s the saturated vapour pressure at surface temperature T_s. The latter can often be inferred, even when not measured.

An extensive investigation was reported by Rohwer (1931), who derived the expression

$E = 0.4\ (1 + 0.27u_o)\ (e_s - e_a)$ mm/day

where u_o is the surface wind in m.p.h., and e_s, e_a are in mm. Hg.

Penman (1948b) later modified this formula to use windspeed at 2 metres height, giving

$E = 0.4\ (1 + 0.17u_2)\ (e_s - e_a)$ mm/day.

Other workers have given values from 0.3 to 0.5 for the constant a in equation (2) (in the same units as Rohwer), with an even wider variation in b.

Part of this variation is undoubtedly due to the different types and sizes of tank employed. Some is also due to the arbitrary measuring heights which have been used for both u and e_a. The remainder arises from the neglect in the Dalton formula of other important factors, some of which will be discussed in the next section.

Visentini (1936) and others have preferred to use in place of the ground-to-air vapour pressure drop the more easily measured quantity $\epsilon_a - e_a$ or saturation deficit (s.d.). Here ϵ_a is the saturated vapour pressure at the bulk air dry bulb temperature T_a. This is based on the erroneous belief that the evaporative power of the air is dependent on its "absolute" dryness as expressed by s.d., rather than its "relative" dryness as indicated by the vapour pressure difference between ground and air.

Although it has no physical justification the use of s.d. as an index of evaporation has apparently given moderately successful results in certain applications, and it continues to be used today, not only in Dalton type formulae (Dzerdzevsky 1956) but also in the construction of climatic indices based on evaporation, e.g., Prescott (1956).

With modified constants the Dalton equation should also hold for natural surfaces other than water. However e_s would have to be directly determined. In the case of a surface not too far removed from saturation a satisfactory measure of T_s might suffice. Probably owing to the difficulty of the above measurements no extension of the Dalton equation to bare soil or vegetated surfaces has taken place as yet.

In principle the measurements required are fairly straightforward. Standard cup anemometers will generally suffice for windspeed. Small units are available, with low friction and low inertia. These have reduced stalling speeds and do not over-run in gusty winds.

Dry bulb/wet bulb methods are generally used for vapour pressure measurement. Standard screen readings with unaspirated thermometers, or even bimetal thermographs and hair hygrographs, are often sufficient for empirical work of this kind. However better results can be obtained by the use of ventilated psychrometers such as the Assmann, or individual wet and dry bulb thermometers so small as to need no artificial ventilation, e.g., fine wire thermocouples or resistance elements (McIlroy 1956).

Recent developments which should prove of value in this field are a crystal hygrometer due to Wylie (1955) and a capacitive hygrometer (Cutting, Jason and Wood, 1956).

(ii) The Aerodynamic Approach

The second approach is essentially similar to the first, but is based on a better physical understanding of the principles involved. It considers the turbulent transfer of water vapour at a small distance above ground, rather than the overall process of ground-to-air transfer. In its basic equation the empirical coefficient of (2) is replaced by the eddy transfer coefficient, and the ground-to-air vapour pressure difference by the humidity gradient, giving

$$E^x = \rho K_W \frac{\partial q}{\partial z} \qquad (3)$$

where E^x is the rate of vertical flow of water vapour due to eddy motion, or the eddy flux, ρ is the air density, K_W is the eddy transfer coefficient for water vapour and q is the specific humidity (i.e., the mass of water vapour per unit mass of air), all at height z.

Up to several metres above ground, storage and sideways flow effects in the intervening air layers are negligibly small, so that E^x is nearly enough equal to E, the actual rate of vapour emission at the surface.

The gradient $\frac{\partial q}{\partial z}$ can be directly measured, so that the problem becomes one of finding a suitable expression for K_W in terms of other measurable quantities. Under most conditions near the ground K_W can be assumed equal to K_M, the eddy transfer coefficient for momentum. The latter is in principle determinable from measurements of the changes in windspeed with height.

Thornthwaite and Holzman (1939), assuming a logarithmic form for the windspeed profile, derived an expression for evaporation involving a windspeed and a humidity at each of two known heights. Apart from height the measurements involved are essentially similar to those required for the Dalton equation. Greater precision is necessary, however, as even small errors in individual measurements can alter the final result considerably.

This technique has been tested by Pasquill (1949b) and others, mostly over open grassland. Weighed soil pots, direct soil sampling and other techniques were used for comparison.

It was found that whenever the height of the vegetation was more than a few inches an allowance had to be made for the upward displacement of the effective surface, due to the trapping of stagnant air in the foliage. This is particularly important with a growing crop, where a new zero-level should be taken every few days. Rider (1954) gives an account of the difficulties met with in using this method over an oat field in England.

For periods of the order of a quarter of an hour Pasquill (1949b) found that a simpler approximate expression, rather resembling the Dalton equation, was quite accurate enough for following the daily cycle of evaporation and the effects of weather changes. Some of his results are shown in Figure 1.

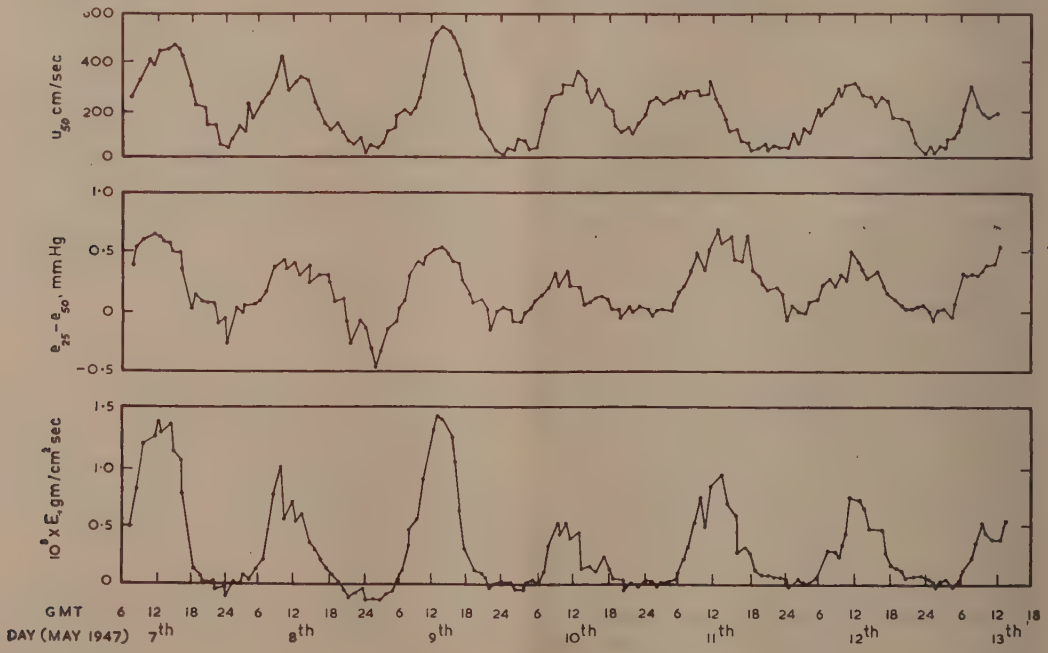

Figure 1.

Hourly values of wind velocity at 50 cm (u_{50}) in centimetres per second, vapour-pressure difference between levels 25 and 50 cm (e_{25}-e_{50}) in mm Hg, and computed rates of evaporation E in gm/cm² sec. Girton Pasture, University Farm, Cambridge, May 7-13, 1947. (Quart. J. Roy. Meteorol. Soc., 75, 249, 1949.)

Strictly speaking the above theory only holds under neutral conditions, i.e., when the lapse rate, or rate of temperature fall with height, is small. The mechanism of transfer is then forced or frictional turbulence. Whenever the lapse rate becomes large the effects of buoyancy begin to play a part, and free or convective turbulence becomes important.*

Such conditions commonly occur during clear days, with strong radiative heating of the ground. Other things being equal they give rise to more effective vertical mixing of the air, and hence increased eddy transfer coefficients. This is particularly so in the case of heat transfer.

The opposite generally holds at night, with a reduction in transfer rates, again the more so for heat. In both cases the effect is more pronounced at low windspeeds.

Under non-neutral conditions, which are often occasions of strong evaporation, a different law of variation of windspeed with height is found to hold (Deacon 1949). Because of this the expression for K_M becomes rather complicated, and requires additional windspeed measurements, of even greater accuracy.

To meet this difficulty Pasquill advocates the taking of measurements very close to the ground, where the effects of buoyancy are less pronounced. Against this, however, zero-level difficulties and sampling variations are both enhanced.

Deacon and Swinbank (1956) have recently suggested another line of approach. Initial measurements made at reasonable heights and under neutral conditions are used to specify a low-level coefficient which does not vary with departures from neutrality, and whose subsequent use does not require an exact knowledge of measuring heights.

For short period measurements both of the above courses should be quite well applicable over any reasonably uniform surface the properties of which do not vary too much from time to time. This would include short to medium pastures, for instance, but not long flexible crops such as wheat which bend over to a varying extent with changes in wind strength.

(iii) Direct Eddy Flux Determination

At any point in the atmosphere turbulent air movement will normally be present, giving rise to a fluctuating vertical component of windspeed. In the presence of a vertical gradient of humidity these fluctuations will be associated with simultaneous fluctuations in moisture content of the air. Rising air will tend, on the average, to be moister or drier than descending air, according to the sign of the gradient. This will give rise to a net transfer of water vapour along the gradient.

The mean rate of this transfer, per unit time and per unit area, is known as the vertical eddy flux of water vapour. Letting a bar over a quantity denote its mean value with respect to time, and a dash the difference between an instantaneous value of a quantity and its mean value, the eddy flux is given by

$$E^x = \overline{(\rho w)' q'} \qquad (3)$$

where ρ, w and q are simultaneous values of air density, vertical windspeed and specific humidity at the measuring point. Hence $(\rho w)'$ represents an instantaneous fluctuation in the rate of upward air flow at the point, and q' an associated fluctuation in moisture content.

Records of ρw and q taken at a point near the ground, examples of which are shown in Figure 2, will permit the direct evaluation of E^x, which is of course the quantity sought indirectly by the aerodynamic approach.

The product ρw can be obtained by hot wire anemometers or similar devices depending on the cooling effect of the air flow over them. q can be obtained via the psychrometric equation from fine wet and dry bulb thermometers.

Equipment of this kind has been in use at Edithvale, Victoria, for some years

*Further reading on these and other aspects of turbulent diffusion could well start with 'Atmospheric Turbulence,' by O. G. Sutton. (Monographs on Physical Subjects, Methuen, London, 1949.)

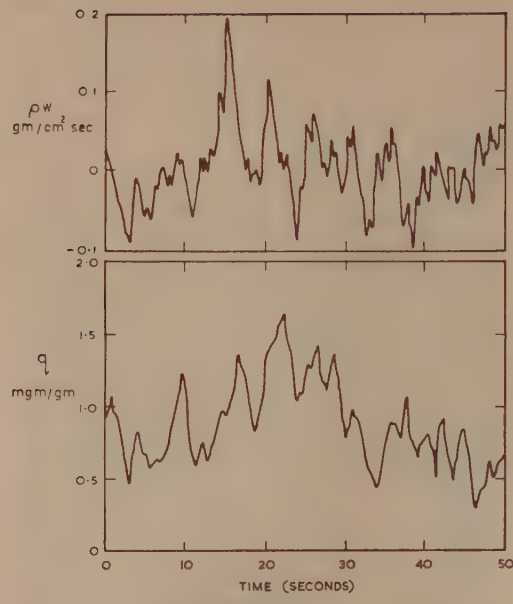

Figure 2.
Fluctuations of upward air flow (ρ/w) and specific humidity (q) at a height of 2 metres above level pasture on a clear summer afternoon. C.S.I.R.O. Experimental Site, Edithvale, Victoria, February 23, 1954.

(Swinbank 1951, 1955; McIlroy 1955). Eddy fluxes are later evaluated from the records of atmospheric fine structure obtained in this way. The procedure is very time-consuming, even with a machine analyser (Taylor and Webb 1955), and cannot be considered suitable for anything but a meteorological research project. However efforts are well under way at the Division of Meteorological Physics, C.S.I.R.O., for the combination of the two functions, detection and computation, in a single instrument which will give evaporation directly as a set of dial or counter readings (Taylor 1956).

It is obviously impossible to measure instantaneous values of ρw and q, but with sufficiently rapid response instruments only comparatively high frequency fluctuations are missed, and these make little contribution to the total transfer.

The actual rapidity of response required for satisfactory flux measurement depends on the pattern and scale of the turbulence. In general the requirement decreases with height above ground and increases with windspeed. It also varies with the roughness of the surface and with certain weather factors.

At heights of a meter or more a response time of about a fifth of a second appears to be adequate under most circumstances. This means in effect neglecting fluctuations much faster than a second in period.

Such a rapid response cannot be obtained from standard meteorological equipment, but is well within the limits of performance of fine wire sensing elements such as mentioned above. However, rather elaborate recording or computing systems are necessary.

Apart from this and the degree of sampling variation likely to be encountered, the method is completely independent of the nature of the surface above which the measurements are made. Much further work is required before regular field use of this technique will be possible. However, there is little doubt that it is even now the best available for accuracy and general applicability.

(c) Surface Energy Balance

Yet another balance sheet involving E can be utilised, that of energy at the evaporating surface, expressed by the equation

$$R = G + H + LE \qquad (4)$$

where R is the net radiation received by the surface and G is the heat flux into the ground, while H and LE are respectively the sensible and latent heat fluxes into the air, L being the latent heat of evaporation.

R is itself made up of a balance between incoming and outgoing components, both short-wave and long-wave. It is often found from a separate measurement or estimation of these quantities, which have importance in their own right in other contexts.

For evaporation purposes, however, it is far better to obtain R directly, using one of several designs of net radiometer

now available (Albrecht 1954, Suomi *et al.* 1954).

These consist essentially of a horizontally exposed flat plate, blackened on both sides and either force-ventilated or screened with transparent material to eliminate the variable cooling effect of natural air movement. The temperature difference between the surfaces (measured by embedded thermocouples), is then directly proportional to the difference in their received radiation. At heights small enough to neglect absorption and emission in the intervening air layer this is equal to the net radiation received by the underlying surface.

G is more difficult to determine but, except over short periods, it is only a small component of the balance, and is often neglected. It can be measured directly by means of heat flux plates buried in the ground (Deacon 1950, Monteith 1956). These are not unlike net radiometer elements and the temperature differences across their faces are taken as a measure of the heat flow perpendicular to them.

Alternatively G can be found from changes in the temperature profile of the soil combined with measurements or estimates of its heat capacity. A typical procedure employs standard soil thermometers for the profile measurement, and laboratory tests on soil samples for thermal capacity. It is rather tedious but avoids such pitfalls as the difficulty of properly and permanently locating heat flux plates, and the errors in their readings due to local distortion of heat flow in their vicinity. In either case the scatter is generally large, requiring a number of measurements at different places to be averaged for a representative result.

The partition of the remaining energy between evaporation and heating of the air has to be approached indirectly, since H is no more readily measured than E itself.

In early work H was neglected (Cummings 1925). This is manifestly wrong, even for a saturated surface. Bowen (1926) considered the transfer of heat and water vapour using transfer coefficients appropriate to laminar flow. He arrived at an expression for the ratio of sensible heat flow to latent heat flow

$$\beta = \frac{H}{LE} = 6 \times 10^{-4}\, p\, \frac{T_s - T_a}{e_s - e_a} \qquad (5)$$

where the new terms are T_a, the bulk air dry bulb temperature and p, the atmospheric pressure. All pressures are in the same units and temperatures are in degrees Centigrade.

Cummings and Richardson (1927) have reported tank experiments which appear to confirm this value for β in the atmosphere. On the other hand direct measurements of turbulent transfer coefficients at heights of about 1.5 metres over grassland (Swinbank 1955) have shown that the ratio of the coefficients for heat and water vapour can vary appreciably.

Pasquill (1949a), in discussing recent direct measurements of evaporation, suggests that under conditions of strong heating the use of the above expression for β could cause errors in excess of 30 per cent. in computed evaporation.

However by working close enough to the ground such effects can be reduced, and it becomes reasonable to assume equal transfer coefficients for heat and water vapour. The so-called Bowen Ratio can then be shown to be

$$\frac{H}{LE} = \gamma \frac{\Delta T}{\Delta q} \qquad (6)$$

where γ is the psychrometric constant and ΔT, Δq are the differences in air temperature and specific humidity respectively, measured over the same height interval.

As with the aerodynamic method the accurate measurement of humidity will constitute a problem. Moreover, at the low operating levels necessary, the area of surface sampled will be small, calling for replicate measurements over any but very uniform ground.

Nonetheless this method appears attractive, particularly since the advent of net radiometers and improved hygrometers.

(d) Combination of Energy Balance and Dalton Equations

Some knowledge of surface properties is required for both the Dalton equation and the energy balance equation using β in its original form (eq. 5). The quantities concerned, T_s and e_s, are not easy to measure, and are rarely available from past data.

Where a known relation exists between them an energy balance equation may be combined with a Dalton type equation to eliminate both of these variables. This has been done independently by two workers, Ferguson (1952) and Penman (1948b). For details of their treatments the original papers should be referred to. They each took the case of a water surface, for which e_s is equal to ϵ_s, the saturated vapour pressure at temperature T_s.

With some further assumptions Penman obtained a fairly simple expression for evaporation in terms of R, T_a, e_a and u. R can be computed approximately from solar tables, plus air temperature and humidity, with figures for either cloudiness or hours of sunshine. The data required then reduce to standard meteorological observations, available from many parts of the world.

Penman's formula has had considerable testing, particularly in Europe, and appears to be quite successful in some localities, but not in others—as might be expected from its large empirical content.

Penman also compared the measured evaporation from similar tanks containing water, bare soil and short grass, the latter two plentifully supplied with water. He found good correlation between them and assigned a multiplying factor of 0.9 to convert evaporation from water to that from bare soil. The factor for turf showed a seasonal variation from 0.6 in midwinter to 0.8 in midsummer.

Using these factors in conjunction with his formula Penman found good agreement with hydrologic balance data for several catchment areas. He also drew up a map of evaporation for the British Isles.

Further modifications to the basic formula have been proposed, to cater for varying roughnesses of surface, the effects of stomatal closure, and so on. (Penman and Schofield 1951; Businger 1956). These, too, have met with mixed success.

Ferguson's treatment was more rigorous than Penman's, and also differed in such details as the formula used for calculating radiation. His equation has had a limited amount of testing, mostly in Australia (e.g., Bonython 1950). It has also been extended to cope with evaporation from salt solutions (Bonython 1956). Modified to suit bare soil and crops it might be expected to give even better results than Penman's. However as yet no worthwhile comparison of the two has taken place.

Conclusion

The measurement of evaporation is at a very interesting stage, although not yet a satisfying one for the field worker who seeks an accurate instrument which is also a practical tool for everyday use.

Until recently only simple methods have been in use, but considerable skill and knowledge were required for their successful application. There is now a trend towards more complicated procedures. These require considerable equipment and some skill in its operation, but give results both more accurate and more directly applicable to the agricultural or engineering problem in hand.

At the present time no simple, direct-reading and widely usable instrument is in sight. On the other hand techniques for measuring such quantities as windspeed, humidity, radiation and so on have recently made big strides. The same is true of our understanding of the relevant physical processes.

As a result a number of channels of approach, some of them known for many years but never fully utilised, are now ripe for exploitation. Others which have long been the mainstay of evaporation investigators the world over are now known to be of dubious value.

For certain limited purposes standard evaporimeters can still be useful. Their results must be carefully interpreted, however, and not extended beyond the rather narrow range of surfaces for which they are representative. Likewise empirical formulae, although of some help where only scanty data is obtainable, should not be expected to apply outside the range of conditions for which they were derived.

For reasons of continuity and comparability of records alone, these devices cannot be abandoned. However, it is to be hoped that the use of the newer methods will not be retarded by conservatism. For although much further work is required for their full development, at the present moment any one of them, properly carried out, is capable of giving better results than the older techniques.

Amongst the latter the only one capable of high accuracy in measuring evaporation from vegetated surfaces seems to be that of lysimetry, using large weighed containers, with adequate moisture control and guard-ring areas. The main drawbacks here are immobility and high cost of installation. In addition, although lysimeters appear simple to operate the complications necessary to ensure representative behaviour can be fully as great as those inherent in vapour flow methods.

Attention should again be drawn to the possibilities, where only moist conditions are being considered, of the simple form of potential evapo-transpirometer mentioned in Section (a) (iii). Where great accuracy is not required the technique of correlating evaporation from crops with that from evaporimeters (Section (a) (i)) is also worthy of being followed up.

There remains scope for moisture profile methods, using the latest developments in soil moisture detection, particularly where such measurements can also be of interest in the study of soils and plants.

There is a fundamental limitation on the short-term sensitivity of water balance methods, due to the daily change in water content of the system being normally a very small fraction of the quantity actually measured, e.g., the total weight of a lysimeter or the total water stored in the soil.

On the other hand these methods automatically integrate all diurnal and weather effects taking place between measurements. Over long periods vapour flow and energy balance methods, dealing essentially with rates rather than quantities, require either continuous operation, feeding into a suitable integrating device, or the averaging of many separate runs on representative occasions. Insertion of daily mean values in the relevant formulae will not give the correct result.

When satisfactory integrating equipment becomes available the eddy flux and energy balance methods should more than compete with lysimeters, over any period of operation. Until then, because of the amount of effort involved, they and the aerodynamic approach are better suited to intermittent or short-term investigations.

Apart from accuracy and sensitivity their particular advantages are mobility, freedom from interference with the evaporation process and comparative independence of the nature of the surface, including its moisture status. In respect of all these except mobility the eddy flux method is superior, with the energy balance method closely following it. In regard to cost and complexity of apparatus required the reverse is true.

In concluding a plea should be made for investigators to include with the actual measurements necessary to determine evaporation a comprehensive record

of the weather, soil and plant conditions. Unless this is done it is extremely hard to compare the results of different workers.

A further need is for direct comparisons of one method with another, which have been singularly lacking in the past.

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THE PROBLEM OF AUSTRALIAN STRONG WHEAT

By G. L. SUTTON

Historical

For some 150 years Australia grew only one kind of wheat—weak wheat—then suddenly, figuratively overnight, she grew two kinds—strong and weak. This has created the problem of adjusting the Australian Wheat Marketing system to provide for selling both kinds in a sound and satisfactory way which is equitable to the seller—the grower—and the buyer, namely, the flour miller. The problem is of such great national economic importance that its solution must be sought with diligence, with understanding, dispassionately and without prejudice.

To reach its present stage of development the Wheat Industry has passed through two eras. The first—the pre-Farrer era—from 1790 to 1900, was one of low yields, and crop failures; an era in which the state of the industry was so precarious that some two years before its close Sir William Crookes, in his Presidential address before the British Association in 1898, felt constrained to point out that Europeans wondered why the pursuit of wheat growing in Southern Australia was continued (Crookes 1899).

Two years after Sir William Crookes made his statement, the second—the Farrer era—was ushered in. This was an era of higher yields; of fewer crop failures because of varieties specially bred to suit Australian conditions. During this era the wheat continued to be noted and unexcelled for its dryness, high flour yield and the whiteness of its flour (Fisher and Jones 1937). Farrer did, however, produce some strong varieties, notably Bobs, Comeback and Jonathan which, however, were never generally cultivated because of their relatively low yield compared with that of the standard wheats. Special or premium prices were paid for these strong varieties, and sufficient was grown to render unnecessary the further importation of the stronger Canadian or U.S.A. wheat or flour for blending to produce better quality bread.

Farrer's ideal and aim to combine good yield and high baking quality in the one variety was not realised in this era. This combination of excellence has had to await the coming of the third era which we have recently entered.

Because of the general progress in the Sciences, but mainly in genetics, the scientific wheat breeders, successors to those of Farrer's generation, have been able to develop wheat varieties capable of producing profitable yields combined with high baking quality, without sacrificing any of those milling characteristics for which Australian wheat had always been unexcelled. In 1935, Fisher wrote "In milling properties, Australian wheat is, almost without exception, the finest wheat that comes to Great Britain".

Australia's Ability to Grow Strong Wheat

In the wheat trading world the standard of high baking quality, or strength, in wheat is Canadian Hard Red wheat. It is described by Fisher and Jones (1932) as the strongest wheat in commerce.

As the result of studies made in the grain research laboratory of the Board of Grain Commissioners, Winnipeg, Canada (Aitken *et al.* 1951) it has become possible to learn how the quality of Australian strong wheat compares with that of Canadian Hard Red wheat.

In addition to field trials, commenced in 1949, the investigations included baking

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quality tests of eight Australian varieties grown in Canada—seven of them strong —and of the grain of seven strong varieties grown in Temora, N.S.W., six of these were the same varieties as six of those grown in Canada, the seventh was Pusa 4. The baking quality of Marquis is the Canadian standard of wheat strength, the grain of this variety was used as the control in the strength tests of the grain of the Australian varieties.

The protein content of the Australian wheats grown in Canada ranged from 12.5 to 14.1 per cent. compared with Marquis 13.7 per cent. As the result of the baking trials of the Australian strong wheats grown in Canada the conclusion was:—

> "The data for the unblended flours show that baking strength (loaf volume) parallels protein content quite closely, a relation quite usual for high grade wheat grown in Western Canada."

The conclusion with regard to the Australian strong wheats grown in the Temora district was:—

> "The results of these various quality tests show that the varieties grown in Australia were, in general, of higher protein content, better in all round baking strength and showed more pronounced dough qualities than corresponding varieties grown in Canada."

This is unassailable evidence, at the highest level, that Australia can grow strong wheat of sufficiently high protein and quality as to rank equal to what is recognised as "the strongest wheat in Commerce".

Have Australians the business acumen to take financial advantage of this wonderful asset they now possess?

It is suggested that suitable names for the two classes of Australian wheat would be:—

"Australian Strong White Wheat," and "Australian Standard Wheat."

It should be noted that this unassailable evidence was obtained with wheat grown *not* in the rich soils of Queensland or the North West of New South Wales—generally believed to be the principal, if not the only, reliable sources of Australian strong wheat—but in the brown earth soils of the Temora district which are typical of large areas in the Riverina and elsewhere in the Commonwealth wheat belt.

Strong wheat varieties are those which contain at least 11 per cent. of dry gluten (protein) of good baking quality, that is capable of retaining the CO_2 produced during the fermentation of the dough.

It is recognised that the *quality* of the protein is determined by the inherent (genetic) ability of the variety to produce it.

As the result of research carried out in Australia and elsewhere there is strong support for the conclusion that the *quantity* of protein in a wheat variety is determined by:—

(a) The soil fertility and particularly by the status of the available nitrogen which must be at a high level to produce strong wheat.

(b) The seasonal rainfall and its incidence.

(c) The variety and, under a given environment,

(d) The yield of that variety.

To produce strong wheat it is therefore essential:—

(a) To plant varieties which are inherently strong.

(b) To plant them in soil with the available nitrogen at a high level.

(c) That the total seasonal rainfall and also its incidence shall meet the requirements of the plant.

When these conditions have been met it has been found that, in Western Australia, strong wheat has been grown on the light "Jam" soils of the Chapman Research Station (Shier and Cullinane 1948).

It would appear therefore that the production of strong wheat in Australia is dependent more upon the use of inherently strong varieties and the adop-

tion of the right farming practice rather than upon the growth of such varieties upon any particular class of soil. It is believed, however, that the strong wheat will be easier to grow and most of it will be grown on the fertile heavier land rather than on the lighter land.

The Demand for Strong Wheat

There is a strong Australian demand for strong wheat. Australian millers need it:—

(a) To produce flour for a better loaf to meet the requirements of the Australian bread consumer.

(b) To produce special types of flour very rich in protein.

(c) For blending with the flour from standard wheat to meet export flour requirements.

There is also an export demand for blending it with their home grown or other wheats to increase the blend to "filler strength".

Australian Standard wheat is sometimes referred to as "filler" wheat. This is a mistake. A "filler" wheat is so called in the British trade because the flour from it is strong enough to make a loaf satisfactory for British requirements. Such a flour, in consequence, can be added straightout to the approved blended grist to fill it out to the required quantity. It is strong enough for the purpose to be used without the addition of stronger flour. For Australian Standard wheat to reach "filler" level it would need to be blended with flour from stronger wheat.

Recently Dr. J. A. Stellenberger (Chief of the Department of Flour and Feed Milling Industry, Kansas State College, U.S.A. (1955) pointed out that European countries are demanding strong wheat and concluded by stating "All indications are that the demands for strong, good quality wheat will increase rather than decrease in the years ahead".

These views are supported by information obtained by Mr. L. H. Dorman, the Assistant General Manager of The Australian Wheat Board, during an overseas tour regarding possible expanding markets for Australian wheat. He reported (Dorman 1955) that in the United Kingdom, Europe, Japan, New Zealand and S.E. Asia there is an excellent and growing demand for strong wheat. He also reported that in August (1955), U.K. buyers were offering a premium of the equivalent of 1/9 (Australian currency) per bushel for Manitoba No. 3 grade Canadian Hard Red wheat. In July (1955), the chairman of the Australian Wheat Board, Sir John Teasdale, told the Victorian Branch of the Primary Producers' Union "We must raise the strength of wheat if we wish to command an Oriental market" (Press report).

To help meet this world demand for strong wheat, there is a very considerable quantity grown in Australia and with the general adoption of "Payment for Quality" this quantity will increase. Producers are quality conscious and will plant more if its greater monetary value is recognised.

In Table I an estimate is made of the production from the strong wheat varieties grown in Australia. Details supplied by the Commonwealth Statistician were used (Commonwealth Statistician 1955). It was then assumed the total yield of strong varieties in the leading ten when compared with the total crop yield would bear the same relation to it as did their percentage area to the total area planted.

TABLE I.

Estimated production of strong wheat in Australia.

State	Total wheat production M. bushels	Percentage area of strong varieties in the leading ten	Estimated production from strong varieties in the leading ten varieties M. bushels
N.S.W.	63.7	34.4	21.9
Vic.	53.7	1.6	0.8
Q'land ..	10.2	85.7	8.7
S. Aus.	30.4	34.7	8.8
W. Aus.	39.7	29.0	11.5
			51.7

Strong varieties other than those listed in the leading ten are also grown so that this estimated yield is a conservative one.

Strong Varieties Do Not Always Produce Strong Wheat

Not all the wheat produced by strong varieties is strong owing to soil deficiencies, the vagaries of the weather and other natural factors. It is therefore necessary to make a deduction for these factors to estimate the probable Australian production of really strong wheat. As will be shown later, a deduction of 50 per cent. is a liberal one. On this basis the probable approximate production of "Strong" wheat in Australia exceeds 25 million bushels. It is known that a relatively small quantity of this is being sold. Mr. Dorman (1955) advises that last season some 4 million bushels were purchased by New South Wales Millers under their own scheme at an average premium of 1/9d. per bushel. In Western Australia nearly 400,000 bushels were purchased by Millers at premiums ranging from 4d. to 1/10d. per bushel and at an average rate of over 1/- per bushel. An unknown quantity of strong wheat has been sold in other States and when this has been accounted for there is still a very substantial amount of the order of 20 million bushels available for use in Australia or for export.

The interests of the National economy as well as those of wheat growers and bread consumers demand that steps be taken to reap the reward of this new ability of Australia to grow "Strong" wheat.

Because of the superior baking quality of the flour from strong wheat, larger loaves can be made from it. This has been graphically demonstrated by comparison of three loaves made, respectively, from "strong", "medium strong" and "standard" flour. The loaf made from the standard flour was less aerated and was the smallest. That from the strong flour was well aerated and was the largest, it was 1¼ inches taller than that made from the standard flour; that from the medium strong flour was well aerated and nearly as large as that made from the strong flour.

The larger loaves made from the stronger flours are also more nutritious because they are more palatable and digestible.

"Strong" wheat is worth more per bushel than "Standard" wheat because more loaves can be made from a ton of its flour than from a ton of flour from "Standard" wheat. Fifty-nine more 2-lb. loaves can be obtained from a ton of flour of which the largest loaf was made. At the local price of 14½d. per 2-lb. loaf this means an increased value of £3/11/6 per ton or the equivalent of nearly 1/6d. per bushel. The farmer selling such wheat could thus receive a premium for it without increasing the cost of bread to the consumer who, at the same time, would benefit by obtaining a larger and more nutritious loaf.

Raising the Quality of Australian Wheat

Two facts are plain:—

(a) Australia is growing strong wheat.

(b) There is a local and world demand for strong wheat.

The problem is to find the means of supplying Australian strong wheat to the people who want it.

There are two schools of thought as to how this is to be done. One has for its objective the raising of the quality of all Australian wheat to the strong wheat level. The objective of the other is the segration of the strong wheat now being grown from the standard wheat and selling it separately.

The Chairman of The Australian Wheat Board (Sir John Teasdale) propounded the first objective. As the first step he proposed that the varieties which farmers would be permitted to grow should be restricted to strong varieties. As a second step, and a necessary corollary to the first, he advocated the improvement of Australian wheat growing practice whereby clover or other legumes

would be grown systematically with wheat so as to maintain or improve soil fertility, particularly its nitrogen content. (Press report, 1955.)

All agricultural scientists will support this latter objective. Since the beginning of the century they have been searching for legumes suitable for rotation with wheat under Australian conditions. The suitability of the wonder plant, subterranean clover, for a large portion of the Australian wheat belt has provided the answer for some areas, and other legumes are now being developed to suit the remaining portion of the belt.

Whilst there may be many who believe it desirable to encourage the planting of Australian strong varieties of wheat, there are also very many who will not support the restrictive method by which Sir John Teasdale proposes to achieve it. This plan is against the Australian tradition of initiative which requires that farmers should grow the varieties chosen by themselves. Any official control of this kind will therefore be resented by growers as filching from them another liberty, too many of which have already been taken.

What would be much more desirable would be for the Departments of Agriculture to decide that no new variety be released for cultivation unless its gluten was of good quality. No possible objection could be taken to such a policy. It follows the Canadian pattern for maintaining the quality of the Hard Red wheat, and is applicable to Australian conditions which are suitable for the production of both "strong" and "biscuit" wheat.

From the practical milling angle, there is also a very substantial reason against the retention of the present system of mixing "strong" and "standard" wheat together. Before being milled each kind requires to be "conditioned" and each kind requires rather different conditioning treatment. To condition the mixture in the most suitable way for one kind would not be the most suitable for the other and would result in loss. The miller, for economic reasons, prefers to condition and mill each kind separately and blend the resulting flours.

It is not admitted that all Australian wheat should be strong, but even if there were a thousand reasons in favour of such a policy there is one final and conclusive reason against it. *It is impossible of achievement.*

It is impossible because wheat strength is influenced by two uncontrollable factors. These are the amount and incidence of the seasonal rainfall and the available nitrogen at certain periods of the plant's growth.

Segregation

Seeing that it is impossible to raise the standard of all Australian wheat to the level of strong wheat, consideration must be given to the proposals of the other school of thought which has advocated the separation of the "strong" wheat from the "standard" and the marketing of it separately. This is commonly known as *segregation.*

The objective of raising the baking quality of all Australian wheat to the level of strong wheat—if it were possible—is a logical reason for opposition to "segration" but that cannot be said to apply to other reasons against that policy.

One such objection raised was that segregation would necessitate the introduction of a grading system. How this could be so when Australia already has and has had a grading system since the introduction of the F.A.Q. Standard? It is true that like the Argentine grading system it is much simpler than the elaborate ones of Canada and the U.S.A. But there is no need to alter the pattern of the Australian wheat marketing system.

Segregation does not mean a change in our wheat marketing system. It involves but a slight adjustment. Apart from the adjustment to provide for an additional quality class so that the strong wheat can be sold separately, there is no change in the marketing set up. As at present

the grade, known as the F.A.Q. standard, will apply to the normal standard wheat, and also, as defined, to the strong wheat and will be the only grade for it. The inferior grades, e.g., "weather damaged", due to the vagaries of the season, will be prescribed, as now, by the Australian Wheat Board.

Another fallacious objection raised against segregation was the illogical statement that segregation meant "picking the eyes out of the crop" and in consequence would injure Australian wheat in its principal markets, Great Britain and Europe. This erroneous idea was debunked successfully by Mr. Ralph Tadman (1953) in a memorandum to the Chairman of the Australian Wheat Board. Mr. Tadman is a member of the London Wheat Committee of that Board and, as stated by Sir John Teasdale, is regarded in London as being the most experienced overseas salesman of Australian wheat. In his memorandum Mr. Tadman was emphatic that Australian standard (F.A.Q.) wheat has been and is bought *not* for its strength but for its flour yield and other excellent qualities, for which it has achieved a desirable international reputation (Fisher 1935). He also warned that to increase the strength of Australian Standard Wheat may deprive Australian wheat growers of some useful customers. So convinced was Mr. Tadman of this that, at one time, he opposed the Farrer policy of improving the strength of Australian wheat. When I met him in Perth in April, 1950, he explained that he feared that this policy would result in the loss of those characteristics for which Australian wheat was so greatly noted. When assured that these fears were groundless he withdrew his opposition and stated that as Australia was in the Sterling area the production of Australian strong wheat might be beneficial to Britain.

The solution of the problem of Australian Strong Wheat is segregation.

As with almost any innovation there are difficulties to be overcome. It has been said that the difficulties associated with segregation are insurmountable. This view is not accepted because the same has been said about other agricultural problems and proved to be wrong.

The need to sell the substantial quantity of strong wheat now being grown in Australia to those who want it, is so great that the difficulties *must* be overcome. The main difficulty is due to the fact that the strong wheat cannot, at present, be separated from the standard wheat as the result of a visual examination, and experience has proved that, owing to the influence of natural factors, the selection by varieties, or by district, is not satisfactory. The only reliable way to select strong wheat is by a chemical test and by one which has regard to the quality as well as the quantity of the protein. Because of this the Pelshenké was advocated until it was learnt that Gabo, one of the best and most popular of the strong varieties, occasionally had a low Pelshenké test. For this reason the protein determination is now favoured provided the varieties eligible for the strong wheat class are those approved by the State Departments of Agriculture as producing gluten of good quality. With this proviso the protein determination is a satisfactory test of strength.

The protein content of the wheat is also the trade standard for strength.

Through the courtesy of Thomas & Co. (W.A.) Ltd., Flour Millers of Cottesloe, their cereal chemist, Dr. Douglas Koch, has kindly made available the protein determinations of the grain of "strong" varieties submitted during the season 1954-55, as being strong and entitled to the premium paid for "strong" wheat. With the exception of Bencubbin with a protein content of 11.05 per cent. and Insignia with 10.85 per cent. all the wheats submitted belonged to strong varieties. The majority were Gabo, a goodly number Wongoody, 5 of Eureka 2, 3 of Yalta and 1 each of Dirk 48, Festival,

TABLE II.

The protein content of the wheat of strong wheat varieties received by the Co-operative Bulk Handling Ltd. (season 1954-5) and which was believed by its growers to be strong.

Batch	No. of Samples	Average Protein per cent.	Range
1	42	12.20	
2	69	11.18	
3	123	11.06	Gabo
4	195	11.15	8.15% to
5	107	11.15	15.58%
	536		
Grand average		11.45	

Kondut and Scimitar. A summary of the results is given in Table II.

It will be seen that the average protein quantity of each batch exceeded 11 per cent. and that the grand average was 11.45 per cent. This would satisfy the requirements for a strong wheat if set as by Japan, at a minimum of 11 per cent. protein.

The range in the protein content of "Gabo" from 8.15 per cent. to 15.58 per cent. confirms the conclusion that strong wheat cannot be selected according to variety and as wheat from many W.A. districts was represented in these tests the results also provide additional evidence that strong wheat cannot be selected reliably according to districts.

Because of the wide range—8.15 per cent. to 15.58 per cent. in the protein content of the notably strong variety Gabo, it is desirable to find a better plan.

If the parcels containing less than 11 per cent. of protein be abstracted from the results given in Table II the summary of the remaining protein determinations is as in Table III.

From the November, 1955, wheat list issued by Drs. D. W. Kent Jones and A. J. Amos (1955) it is seen that the cargoes of No. 1 Northern Manitoba wheat, (Canadian Hard Red) arriving in the U.K. during that month, had an average protein content of 12.48 per cent. (maximum 13.00 per cent., minimum 11.97 per cent.). The overall average of 12.69 per cent of the Australian strong wheat parcels in Table III compares favourably with this. From the same list it is seen that the average protein content of Australian cargoes was 9.63 per cent. (maximum 10.77 per cent., minimum 8.55 per cent.). This average is 3 per cent. less than that of the strong varieties in Table III and emphasises the need for segregation.

There is no logical reason against segregation. The buyer who "calls the tune" suffers no disadvantage; he can buy "standard" or "strong" wheat best suited to his purpose or, if he desires a blend of both, he can purchase them separately and blend them to meet requirements.

It benefits the grower by creating a greater demand for his product as the result of offering the prospective buyer

TABLE III.

Protein content of strong varieties submitted as strong wheat, season 1954-55, *containing* 11 *per cent. protein or more.*

Batch	Gabo		Wongoondy		Sundry		All varieties	
	No. of Samples	Average	No. of Samples	Average	No. of Samples	Average	No. of Samples	Average
1	20	12.72	12	12.88	—	—	32	12.72
2	42	13.74	19	12.56	2	11.70	63	12.68
3	40	12.59	14	12.54	2	13.85	56	12.63
4	65	13.02	36	12.39	10	13.14	111	12.82
5	37	12.45	17	12.44	5	13.06	59	12.49
	204	12.75	98	12.51	19	13.01	321	12.69

a better opportunity to choose the type of wheat he needs.

Unexpectedly, support for segregation comes from the other side of the world, from the U.S.A., the largest wheat producing country in the Western world. It comes from Dr. J. A. Stellenberger (1955), an unbiassed specialist on the utilization of wheat for flour and stock feed. He stresses the need *"to prevent the debasement of good wheat by admixtures of poor quality wheat or foreign material and to segregate wheat on the basis of protein, variety and baking quality considerations."*

Export Standards

Having segregated the strong wheat so that it can be marketed separately, it will be necessary to market it in such a way that the prospective buyer will be convinced that it really is strong. As Australia has been producing and selling only standard wheat for some 150 years he may hesitate to believe that Australia can also produce strong wheat.

It is suggested that the best way to do this is to provide export standards for wheat as has been done so satisfactorily with other agricultural commodities like fresh and dried fruits, butter and eggs. These standards should have their characteristics defined in definite but simple language understood by growers and prospective wheat buyers, and in terms used in the International wheat trade, not in terms of our own making; such may be misunderstood to the financial detriment of the growers, as, for instance, to refer to "under grade" wheat when quite good wheat of second quality is meant.

The suggested "Baking Quality" standards for export wheat are that the Australian strong wheat shall contain not less than 11 per cent. protein of good quality and the Australian standard wheat shall be wheat other than the strong wheat.

The "Milling Value" standards should be designed to prevent the reduction of the value of the millable wheat by the presence of unreasonable amounts of unmillable or deleterious material.

The need for the selection of Australian Strong wheat by a chemical test will require the establishment of additional laboratory facilities and the appointment of qualified staff. Laboratory facilities are one of the tools of trade of a "Big Business" organisation handling some 160,000,000 bus. of wheat annually. They are necessary so that its executive shall be as fully aware of the characteristics of the wheat as are its trade rivals and overseas buyers.

Conclusion

It is futile to say that segregation is impossible. It is already functioning to a limited extent in New South Wales and Western Australia to the advantage of a relatively few growers. By the adoption of similar methods it can be extended so that the majority of growers may benefit wherever their wheat is grown.

To avoid delay at receival depots these methods will involve a simple selection test before arrival and, because of the limitations of our bulk handling system, temporary storage at the receival depots will be required prior to despatch to a central depot or port for local sale or despatch.

Though time and improved facilities may bring refinements, such as segregation at different protein levels, I am firmly convinced, as a result of a study of its problems and experience of wheat marketing for some forty years, that, even with present facilities, segregation, as outlined, is practicable for a large proportion of the strong wheat produced in Australia, if and when we have the will to introduce, organise and administer it.

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(*Received for publication, March* 10, 1956).

BOOK LIST

Notice has been received that the following books on agricultural topics have been published recently:—

ADVANCES IN AGRONOMY, VOL. 7.—Edited by A. G. Norman, *New York, Academic Press Inc.*, 1955.

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SEARLE, Sidney A.—The measurement of plant climate. *Chichester, Chichester Press Ltd.*, 1953, 7/6.

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BOOK REVIEWS

THE PLANT QUARANTINE PROBLEM

By W. A. McCUBBIN

In attempting to present a comprehensive survey of the vast subject of plant quarantine, dealing with the biological, legal, administrative and public relations problems inseparable from its application, Mr. McCubbin has drawn extensively on his wide experience of the situation in the U.S.A. where he served with Quarantine for over thirty years.

In illustrating the principles which are enunciated in a very lucid manner, the author has given many illuminating examples and throughout the book every conclusion drawn is well supported by adequate documentary evidence. The historical summary of Federal plant disease quarantines given as an appendix is of itself a most valuable explanation of and justification for plant quarantine as a positive means of protecting the agricultural prosperity of a nation.

To those engaged in plant quarantine activities throughout the world the book will prove to be invaluable for reference purposes even if the problems dealt with in the book differ in detail in each country. It should be a valuable book of reference for all students of agriculture in Australia and should find a place in the libraries of all research institutions.

T. H. HARRISON.

THOUGHTS ON FARM MANAGEMENT STUDIES

By C. H. DEFRIES

"Then it follows that . . ." What an achievement it is for a scientist to reach that stage in his investigation. Those of us who are now becoming concerned with farm management problems are aware that our conclusions will require very careful formulation. Since in Australia this branch of study is still an infant, though we hope soon to be a lusty one, we might well glance at some of the pitfalls likely to be encountered, and the nature of the conclusions it can reach. In the process we can raise in the tentative fashion that befits its status certain considerations about the use of a tool which may well be important in the future of our agriculture.

There is a need for much more discussion of farm management investigation problems than we've had. Workers in this field are few and scattered. Exchange of views is difficult. This article is written in that spirit. And in the hope that it will serve as a stimulus to the general type of discussion that is needed at this stage of development in Australia. In other words, there is a place for thinking out aloud before we go much further.

The discovery that there are such tools as farm management techniques has been very belated. The reasons need not detain us long. They have been outlined by Campbell (1955) as uncertainties of production, the high rate of technological advance overshadowing need for efficient use of resources, the general nature of the training given to agriculturists and the extensive nature of our agriculture. It is also true that in many areas the farm structure itself is only now reaching a stage of maturity where management considerations directed to efficient use of resources become essential.

There is, however, another factor of particular importance because it has a bearing on the use of farm management techniques, i.e., the tendency for farmers to aim for security of income rather than maximum income. That the farmer's aim is to maximise his income is the underlying assumption of much farm management work. This is particularly the case with mathematical techniques. In fact, maximum income is not always or even often the major consideration. Farmers today are as much concerned to draw a secure income from their farms as a maximum income. Or to put an even finer point on the question, farmers do not mind having a risk enterprise or two on the periphery of their farm pattern so long as the main part of the output is as free as possible from risk either of production or marketing vagaries. The element of risk, which is often the least calculable of influences, can therefore exert a decisive influence on the adoption of any suggested enterprise pattern. Having said that, it must also be agreed that to know in quantitative terms what the results would be from various combinations provides a very useful bench mark from which to balance security against insecurity.

However, to put the best possible face on it, the delay enables us to make good use of American and British experience in this field. We may hope in view of this experience to skip as lightly as may be across some of the grosser traps that lie before us.

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What is Stimulating Interest Now?

The reasons for the appearance of an interest in farm management just now might, however, be spared a moment. This is the more desirable as it permits us to observe how the proportion of the whole cost structure represented by costs incurred within the farm fence, and consequently subject to some degree of control by, *inter alia,* management, is declining whilst the proportion represented by costs incurred between the farm gate and the consumer, and consequently beyond his control, is increasing.

The reasons are briefly as follows:—

(1) The transformation which has taken place in recent years in the market situation. An era of secure overseas markets has given way not only to price reductions but also to considerable uncertainty. Consumer pressure on rising prices within Australia combined with rapidly rising costs complete in broad outline the situation now commonly referred to as the cost-price squeeze.

(2) The technical revolution itself while overshadowing in its initial stages the need for efficient use of resources has also, particularly in relation to mechanisation, so increased capital investment that the situation is now more akin to what is found in the industrial firm. Waste begins to take on an importance it has never previously had in Australian farming. This, of course, is reinforced by the labour shortage and higher labour costs which now prevail. And is again accentuated by the higher degree of skill required for the more elaborate equipment which is available.

(3) Associated with the above is the question of inflated capital values. Surely one must believe that neither banks nor intending purchasers could have allowed such fantastic absurdities in the way of farm selling values as were perpetrated in the late 1940's and early 1950's had there been the semblance of awareness of possible levels of productivity and returns from investment.

(4) Finally it is desirable to realise how much attention is being directed on the need to reduce internal and controllable costs because of increases in freights, etc. For instance, the return which the Australian grower receives for grain has declined much more rapidly during the last few years than has the selling price at principal overseas markets. Costs incurred after the grain passes from the hands of the grower until it reaches the country of destination are taking an increasing proportion of the final selling price. Shipping freight, local transport and wharf costs and general marketing costs of wheat rose from 24.6 per cent. to 48.5 per cent. of the c.i.f. U.K.-Continent price between June, 1952, and June, 1956. This means that control can at best be exercised only over elements of cost comprising about half of the selling price overseas.

Farm Management Techniques

Farm management techniques are means whereby you can find which combination of available enterprises, which level of available inputs, and which of the available systems of producing a crop will maximise profits and make the most effective and economic use of the limited resources a farmer has at his command.

Farmers have always had to manage their farms. This means they have had to reach decisions about management problems. So that what this type of study proposes is not that something new should be done. Farm decisions are usually based on the rough and ready judgments of the individual farmer and consequently vary greatly in quality according to the experience and business acumen of the individual. Very rarely is he equipped with adequate data about his farm. When capital requirements were not heavy and when the other factors previously mentioned were not operating this method worked. It is still quite effective where the differences in

profitability of various practices or enterprises can be clearly picked out. Farm management techniques purport to handle these mental processes in a systematic way.

The farm management specialist should be able to assist the farmer in this particular problem just as do the agronomist, the soil conservationist, the entomologist, etc., in their particular fields.

Above all it is the task of the farm management specialist to point to the functional relationships which exist between the various parts of the farm. There is no part of a farm which is not functionally related to some other part and to the whole. This establishes both the need for the analysis of these relationships, in quantitative terms if possible, and also gives rise to the difficulties encountered in the task.

The Dangers Involved

As we propose to substitute a formalised approach for the farmer's own more or less loosely achieved decisions we need to be fully alive to the dangers involved. This is the time to examine these closely, or as closly as we can in view of our limited experience. This is especially so as mathematical procedures loom large, particularly in United States literature. Mathematics is a very attractive looking tool, but the more profound the formula the more we need to cling fast to the practical realities of the farm situation. The dangers rapidly increase in potency when we call on the aid of higher mathematics.

We should look very closly at the nature of farm data. Do we fully understand what its limitations are? Do we know, for instance, to what extent its units are discrete or continuous under practical farm conditions? Attention to questions such as this is one of the urgent preliminary tasks to be performed.

It is by no means clear how far any particular input can be allocated to a particular enterprise. We run into all sorts of problems here concerned with the residual effect of fertiliser on crops and the effects of stock on long-term conservation measures. When stock are necessary for a soil conservation programme their income value is by no means easily measured.

The assumption of linearity (the assumption that each increment of input will produce equal outputs) needs to be checked very carefully when using the linear programming technique. This technique is an extension of simple budgeting which provides a method of choosing a combination of enterprises that will maximise net income from a continuous series of possible combinations.

There are many farm operations where linearity simply does not hold. For instance, the rate of spraying on a pineapple plantation will certainly not follow a linear progression. Two men do considerably more than twice the area that one man can do and three men do more than half as much again. More important perhaps, the treatment of machinery can also easily break through the boundary of valid inference. In the practical farm situation the farmer has not often available to him a continuous series of choices. He either has no milking machine, a two-stand plant, a four-stand plant and so on. He buys either a 20 h.p. tractor or a 25 h.p. tractor. Furthermore, it is rare to find machinery used to optimum capacity. At levels below this capacity input coefficients per unit of product will tend to vary rather than remain constant. These factors throw emphasis on the need for caution when using techniques which assume fixed input coefficients.

Interpretation and Other Hazards

Interpretation should also keep us alert. Statistics can often be used far more effectively to describe what the facts are than to provide a solution to the problem. Measurement is one thing, interpretation another.

Climate can play a major role in complicating farm management studies. The weather is a notorious upsetter of con-

clusions. Consequently, for this as well as for other reasons, it will be of the utmost importance to know what effect variations in any of the coefficients are likely to have on final results. Furthermore, as indicated previously, the assumption on which these input-output coefficients is based is that certain outputs of products will automatically follow certain inputs. Even if we disregard the variation possible at various levels of management skill there is still a good deal of room for variation arising from chance elements other than weather.

We are dealing not only with a large number of variables but also a high order of unpredictability. An unexpectedly heavy insect infestation or disease incidence for instance. Or even a tractor breakdown at a crucial time for planting. Luck is a factor in farming.

Some authorities in the United States are disturbed at the trend towards an over-refined mathematical approach, e.g., Schultz (1956), commenting on progress made in production economics, says—"It is true that simple, old fashioned budgeting has been replaced by sophisticated production functions, and the journals runneth over with 'results' from linear programming, a new apparatus that is turning out, thus far, an undigested mixture of a few insights and many 'numbers' that do not make sense".

And in fact mathematics needs very careful digesting before it is allowed to flow into the agricultural system. Sometimes you get the impression that a fretsaw is being used to cut down the tree.

Selecting the Tool

At this stage of our knowledge it may be that we should concentrate our attention on the simpler type of approach. Good results are to be obtained from casting together a series of indices to draw attention to desirable patterns of input/output relationships. These may be standards representing regional averages; on the other hand they may be results drawn from a representative sample of the more efficient farmers in a district. A farmer, armed with appropriate records, may compare the performance of his own farm with these averages. This has, however, a dangerous air of simplicity. It is strictly a down to earth approach and the equipment required by those engaged in it includes a comprehensive array of qualifications, both practical and technical. An agricultural economist should have his feet firmly established in both of the two spheres of thought his title refers to.

This does not necessarily mean that we should ignore the more complex mathematical approaches such as linear programming. Rather should we examine carefully the precise nature of the situation in which they are appropriate.

Choosing the most efficient method of approach is something in the nature of an economic problem itself. There will be many instances where practical choices available are so limited as to render the use of a series of budgets equally if not more effective than linear programming. This seems to be particularly so when the budgets are used in conjunction with indices. In applying mathematics to farm data it is often found that 90 per cent. of the calculations are required to add only a very small, and possibly unnecessary, increment of accuracy to the result obtained.

The Functional Approach

At this stage it may be useful to examine one aspect of farm management work which can be of immediate practical value to us all. There is no question but that the newer mathematical techniques direct our attention more effectively than any other to the functional relationships of each sector of the farm. That provides a valuable tool of thought which can be used alongside the specialist approach that has been customary. Even the general field adviser tends to see only particular aspects of the farm, and indeed there are sound reasons for this. But the farm is a unity and both field men and farmers need a much livelier appreciation of this than they have. Secondary in-

fluences strike us more forcibly when we consciously accept the need to examine what other changes take place as a result of the particular change advocated.

Linear programming has this great virtue that it shows us a way of thinking about the nature of these repercussions. Where its use is valid it also provides a tool with which the relationships can be expressed in quantitative terms.

But even if the mathematics is not justified because of the nature of the basic data or other limitations it is still the fact that this type of approach holds great promise. From it we can pick up a useful twist or two about management. Inadequate data does not obviate the need for decisions to be made. It only makes them more difficult to reach. There is certainly nothing obvious about the proportion in which beef, butter, lambs, wheat, sorghum and all the other crops available, should be combined on the Darling Downs so as to maximise income and make the fullest possible use of the resources available to the farmer. We hope that farm management studies will help to throw some light on the problem. But in the meantime even an awareness of the funtional relationships involved is a help.

Much the same type of analysis is becoming increasingly used in national and industry economics to estimate changes in inter-related factors consequent on any particular development or to show where development could most efficiently take place in the economy.

Conclusions

We have to avoid undue simplification of the farm management problem. Situations abound where adding up two and two just doesn't give the results we require. On the other hand, there is always the danger of unwarranted complication when we substitute more elaborate mathematical procedures for simple arithmetic. Sometimes the work, particularly if the result is mathematically significant enough to be reliable, will show that it is what either cursory observation or close qualitative analysis could have reached in the first place. Even here the conclusion may be all the better for a mathematical prop. It is handy for an extension officer to be able to drive his argument home with a figure or two. And the analysis may well shake out a fact which would not have risen up before an observer leaning up against the fence.

We want to provide extension workers with convincing arguments in the way of facts and figures to facilitate the task of achieving the cost reductions in agriculture on which its well-being depends. In the event of our throwing up arguments which support some particular group's reluctance to adopt "better" methods let us hope that we can all take that in our stride.

In brief, what is aimed at is an alternative to rule of thumb approaches and to unconsidered panic decisions resulting from market changes. Australian farming needs a more effective approach to the use of new techniques than their adoption merely because of their prestige value, and to purchase of machinery merely because it is new machinery. A counter is needed for what is frequently the unwise reduction of expenditure in response to economic troubles, such as reducing fertiliser applications on the grounds that they cannot be afforded.

The use of farm management techniques does not imply that there are not other important considerations in determining a farm programme. A farm is more than just a business. It is a farmer's home and his life. It gives him intangibles such as a quality of freedom and a close and intimate contact with natural forces, which often amount to a worth-whileness ranking high above profit. But farms are small firms and there is an advantage in breaking off that part of a farm which has business aspects to turn it over in our hands as it were and give it a closer look.

This is particularly so with our typical family farm. It is labouring under increasing handicaps in this age of machine

and technique. Mechanisation is indeed a problem zone for much of our farm industry. There is a traditional reluctance to adopt co-operative practices as a means of overcoming some of these excess investment situations. Management studies may well define more clearly in terms of facts and figures the nature of the limitations imposed on farms of various size groups.

Farm management study hasn't got very far yet, but provided those of us who will be ploughing this field remember to keep our purpose clear there is no reason to believe that it won't have a future in Australia. The aim must be the very down to earth one of assisting the farmer to reach his production decisions, to help him organise his operations, and finally to guide him in the most economic use of new techniques and new equipment.

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BOOK REVIEWS

ORGANIC INSECTICIDES

By Dr. R. L. METCALF

(*New York, Interscience Publishers, Inc.*, 1956. $8.50)

This may be regarded, in a sense, as a companion volume to Metcalf and Flint's "Destructive and useful insects, their habits and control," and is equally essential to the serious student of insecticides. The earlier book, of course, deals with the practical application of insecticides and the control of specific pests. The new book deals with the chemistry, relation of structure to toxicity, mode of action and mammalian toxicology of insecticides, and is thus in a sense a companion volume to Dr. Horsfall's recent "Principles of fungicidal action."

The book deals in turn with the nicotine family, rotenoids and pyrethroids, organic thiocyanates, dinitrophenols, DDT, BHC, and various acaricides and miscellaneous insecticides; virtually all insecticides of modern importance are dealt with, each under the points given above. A long chapter on the organic phosphorus insecticides emphasises the importance this group has attained in the last decade. Dr. Metcalf appears doubtful whether the insect/mammal toxicity ratio can be much further improved in this group owing to the apparent similarity of the bio-chemical processes affected in the two types of organism. This is more pessimistic than some, although probably justified on the weight of evidence.

There is also an interesting chapter on the synergism and the joint action of insecticides, naturally with particular reference to the most explored field, pyrethrum synergists. In the introduction to a final chapter on the important question of insecticide resistance, Dr. Metcalf points out once again that most investigators now believe that the insecticide acts by selecting naturally occurring resistant mutants, and not through sub-lethal dosages causing new resistant mutants to arise. The latter is a rather widely held belief.

Lesser mortals who have visited him at his laboratories at Riverside, California—probably the best of their kind in the world—can only wonder how Dr. Metcalf (not forgetting Mrs. Metcalf's very positive aid) can find time to produce books of this calibre among his many other preoccupations.

AGRICULTURAL RESEARCH LIBRARIES

By C. SCHINDLER

Summary

The special problems of agricultural research libraries are described. The services which should be provided, staff requirements, some factors involved in costs, administration problems and extension of services beyond the organization are discussed. A selected bibliography is given.

General Considerations

A technical library is necessary for efficiency in any kind of pure or applied scientific research. There are many problems common to all such libraries, but agricultural research libraries have their own special problems. The wide range of subjects involved in any agricultural research is one of these. The information on these subjects is to be found in a wide range of books and periodicals, and therefore a large number of these must be available, together with the reference works required to facilitate their use. These should be in charge of a person with sufficient special subject knowledge to organize and use them most effectively.

The work of an agricultural research organization is often carried out at one or more field stations as well as at a central headquarters. It is therefore necessary to provide suitable library services at these stations, properly co-ordinated with those at headquarters, but without any unnecessary duplication of material.

Most institutions are not concerned solely with research. The activities of a government agricultural department also include administration, extension and other work. A firm concerned with the manufacture and sale of fertilizers and agricultural chemicals will not only carry out research on their manufacture and use (which are two independent subjects in their own right), but will also require information on the laws relating to them, and on advertising and general business methods. In such cases, information on many subjects other than those related directly to research will be required, and the library organization must be extended to include them.

Library Services

Some research workers think of a technical library solely as a source of supply for a particular book, periodical article or report, and others use it to obtain information on a particular subject. These limitations on the use of research libraries are often due to lack of sufficient staff to enable further services to be provided.

A trained librarian can obtain the maximum information from available material and make use of sources of information outside the institution. Checking of previous research work may save duplication and the resulting waste of time by research workers. A good library service can attract good research workers, who appreciate prompt supply of reliable information. A manager of a research and development laboratory in the United States said that one branch of library service alone saved 800 hours yearly of technical workers' time at a cost of 300 hours of library time.

Most libraries serving agricultural research workers have some arrangement for the circulation of periodicals to the staff, and issue lists of books and pamphlets available for loan to them. Specified works are lent as required; some requests involve borrowing from other libraries. Staff members may require advice on

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general reading or on some subject relating to their work, and the librarian can usually recommend suitable books by consulting the book catalogue and printed indexes. Reference work includes the answering of questions from reference books and also the supply of references to periodical articles, books and pamphlets on special subjects. Both special subject knowledge and library experience are necessary for this work. Facilities should be available for quick copying by a photographic method of papers required for continuous reference and of those borrowed from other libraries. It should be possible to supply translations by the use of indexes of those already made and available, and by arrangement with a competent translator. The library may maintain special indexes, such as a continuous index to the institution's publications. In addition to these normal services, the library may handle orders for other branches of the organization, including the receipt, checking and re-direction of periodicals. This kind of work may make serious inroads on the time available for true library work.

Other services which can be useful to research workers are the preparation of abstracts of articles on a subject and of a review of a subject. These take a great deal of time, and require a knowledge of the resources of abstracting and indexing periodicals and of abstracting methods. Such an abstract bibliography or review would be very useful to a research worker in planning a new project, as it would prevent duplication and indicate useful lines of investigation.

Accession lists and the circulation of periodicals make information available to research workers, but a technical library should be able to bring the latest information to their notice as soon as possible after publication. In some organizations the library staff scan all literature and note items of interest to individual workers. For this work, the library staff must keep in close touch with all research workers and with their present and future projects, and be familiar with the type of material published in the various periodicals available.

A great deal of professional and clerical work is necessary to ensure the supply of the required material to the library, and for the classifying, cataloguing and indexing required to make it fully available. These processes will not be discussed here, as they are the concern of the librarian. A trained librarian, with adequate staff for clerical work, can do this most effectively. Recognised library technique is designed to make information readily available, and is the most satisfactory basis for the operation of an agricultural research library as of all others; of course, modifications are necessary for special subjects and for full exploitation of periodicals and pamphlets as well as of books.

Staff

The above discussion on the functions of an agricultural research library indicates that the librarian should have a wide (but not necessarily detailed) knowledge of agriculture and the related sciences, so that he can organize the information most effectively, understand the requirements of the research workers, and discuss their problems with them in order to determine accurately the information required. He must also be familiar with library methods, so that he can select the most useful for his particular requirements and use standard catalogues and indexing journals. The examination syllabus of the Library Association of Australia provides for the requirements of special types of libraries, and a librarian's efficiency will be greatly increased by studying the appropriate parts of this. Knowledge of the working of the organization which the library serves is also necessary. If abstracts and reviews are to be prepared, a course of precis writing should be studied.

Sufficient clerical assistance should be provided to enable the librarian to spend all his time on professional work. Apart from normal library work, he should be

able to keep in touch with the needs of research workers, prepare and organize additional services, and ensure that new information promptly reaches those who can use it.

The status of the librarian in the organization varies greatly. Some time ago a firm with wide interests in agriculture advertised for a librarian who would be expected to spend part of her time on general typing work. A person who would accept such a position would probably have neither library nor special subject knowledge, and would have no incentive to obtain either. On the other hand, the National Institute for Research in Dairying (Shinfield, England) has a properly staffed library, which compiles detailed indexes of dairy literature and notes items of interest to individual workers as well as carrying out all the usual library functions. The efficiency of this library and of the librarian is indicated by the unusual action of J. G. Davis in dedicating his book, "Laboratory Control of Dairy Plant" to the librarian as "a small appreciation of never-failing help". The C.S.I.R.O. salary scales for librarians are based on those adopted for technical officers. This has attracted efficient personnel, and has probably contributed in no small part to the ability of about forty libraries to cover all the requirements of its research workers in a wide field of pure and applied sciences scattered throughout Australia.

No general rule can be given for the number of persons required to staff a library, as the requirements vary greatly. A British survey of special libraries in 1946 gives an average of six for a library which handles 10,000 loans per year and provides other services satisfactorily.

Costs

Costs of a library service can be first divided into capital costs (buildings and equipment) and running costs (salaries, books, binding, stationery, etc.). It is difficult to separate some of these from the general costs of the whole establishment. Some rather expensive items of equipment (e.g., copying machine, duplicator suitable for cards) will save a great deal of time, thereby enabling better service to be given. But the requirements of the whole organization should be considered when selecting expensive equipment so that the greatest possible use can be made of each machine.

Of the recurring costs, salaries will ultimately determine the quality of the staff, and therefore of the service. Subscriptions to periodicals are an important recurring cost, and also involve recurring binding costs. As broken sets are a complete waste of money, the choice of periodicals must be made carefully. No subscriptions should be made without consulting the librarian. If a periodical which will not be used a great deal is abstracted by the relevant abstracting journals, and can be borrowed when required from a convenient library, a subscription is a waste of money. Co-operation with other libraries in this matter directly and through union catalogues is desirable. A great deal of wasteful duplication can occur where branch libraries are maintained. An organization which has its own publications can often save subscriptions by arranging exchanges with useful periodicals. Books are expensive, but the purchase of one does not commit the library to future expenditure. The number of books bought can be reduced to a minimum consistent with efficiency by remembering that in a research organization the latest information is the most valuable, and this is available from periodicals by the use of the indexing and abstracting journals.

The permissible annual expenditure on technical information services in company libraries has been variously estimated at from one to five pounds per employee, and also at between two and five per cent. of the total research expenditure. These varying estimates, and the different bases of estimation, show that no exact figure can be given; the position is still more indefinite in government and

other organizations whose activities are not based on the profit motive.

Administration

All technical libraries should be responsible directly to management and administration, or form part of a division so responsible. This enables them to give full service to all divisions. If the librarian participates in staff meetings or sees the minutes of such meetings, he can obtain information on the possible requirements for future projects.

The wide range of subjects covered by some agricultural research institutions often leads to the accumulation of collections of books and periodicals by small groups of specialist workers. They are usually independent of the librarian, and are not properly organized for most effective use. Many publications held in them cover a wider field than that required by the small group in possession, and the information is not available to other groups to whom it would be useful. The latter may remain ignorant of this, or may overcome the difficulty by obtaining additional copies for their own use. Field stations require their own libraries, but these should be controlled from the main library, to ensure that their contents are recorded and are available elsewhere if required. This system is in use in the New Zealand Department of Agriculture. Another institution, on the other hand, has at least 25 small independent collections of books and periodicals at its Head Office alone.

Proper cataloguing and general availability of material can be combined with easy accessibility of specialised works to those using them frequently by a system of permanent, extended or indefinite loan. In this way complete records of all books are made and kept by the library, and specialised material is lent for an indefinite period to persons and groups using it continually. It can be recalled for short periods for use by others as required, a complete record is kept, and wasteful duplication prevented.

Most periodicals are of use to workers in different subject fields. They require the use of abstracting and indexing journals (and perhaps of special indexes also) to enable them to be properly exploited. They should therefore all be kept in the library, under proper control of the library staff with experience in the use of the indexing journals and in the compilation of any special indexes required. This also enables efficient circulation to be arranged, using the minimum number of copies. If a particular article is required for permanent reference, an extra copy of the issue containing it, or a reprint, can be obtained or a photocopy made.

Extension of Services

The extension of services beyond the organization depends on administrative policy. In a company library, it is necessarily limited by staff and other considerations. However, even in these a certain amount of outside service is good policy, as it develops goodwill of both individuals and institutions. The material held by agricultural research organizations is usually highly specialised, and is therefore not in great demand by the general public. As it may be required urgently at any time, outside loans would not be encouraged. When made, prompt returns are usually required. Any considerable extension of library services involves increased book stock and staff.

Some agricultural departments are able to extend library services on a large scale. The Central Agricultural Library of the South African Department lends books, bulletins and periodicals to farmers, government officers and organizations; over 30,000 such loans are made annually. No deposit is now required from farmers, farm schools and organizations, and loans are post free both ways.

The New South Wales Department of Agriculture Library provides services to universities and other teaching and research organizations. In Queensland, the Department of Agriculture and Stock normally makes loans only through other

libraries, but co-operates with the Country Extension Service of the Public Library in answering subject enquiries and in supplying departmental publications.

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(These are not intended as authorities on library methods, but rather for administrators of institutions carrying out research work and for research workers interested in library organization.)

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BOOK REVIEWS

THE STORAGE OF SEED FOR MAINTENANCE OF VIABILITY

By Dr. E. BIASUTTI OWEN

Commonwealth Bureau of Pastures and Field Crops, Hurley, Berks.

With a chapter on the Genetical Aspects of Seed Storage by T. Ashton, M.A.

Commonwealth Bureau of Plant Breeding and Genetics, Cambridge, Cambs.

Bulletin 43 *of the Commonwealth Bureau of Pastures and Field Crops at* 25/- (*Australian*).

This is a review of the literature on the storage of seeds against loss of viability, particularly as it concerns the small quantities of seeds stored by plant breeders. It deals with the longevity of seeds of field-, pasture- and horticultural-crops, and some wild plants, and with the factors affecting their viability. No geographical limit has been set.

Particular aspects of seed storage, such as the changes in the respiration and chemical composition of seeds; the conditions suitable for the growth of fungi; dormancy, hardseededness; seed treatments; and the genetical aspects of seed storage have been considered. Relevant information of general interest derived from the literature on the storage of large bulks of seed has been included, but this type of storage has not been dealt with fully as it is already covered by other publications on the subject. The storage of seeds of forest trees and of perennial plantation crops is not considered.

This publication is intended to meet not only the needs of the scientist who wishes to keep a stock of valuable seed in a viable condition for a number of years, but also the less exacting needs of others who seek information on the longevity of a particular type of seed or on its storage for a limited period of time.

There is a bibliography of some 375 cited references.

Orders may be placed with the C.A.B. Liaison Officer, c/- CSIRO, 314 *Albert Street, E. Melbourne C.*2., *Victoria.*

MUTATION PLANT BREEDING

By R. D. BROCK

Introduction

The improvement and adaptation of plants for man's use has from the earliest times been closely associated with the evolution of civilization. It is not surprising therefore that with the advent of the atomic age we should be considering new techniques for plant improvement.

The technique of plant improvement throughout the ages has been to select from the store of variability within the species, the plants best adapted to the environment provided by man. At first the variability was that occurring in man's immediate surroundings. This was supplemented, initially, by the importation of plants and seeds from distant areas; later by the discovery that hybridization releases a store of hidden variability; and now by the use of mutagenic agents. Mutations are permanent genetic changes and naturally occurring variability results from the accumulation of spontaneous mutations which occur with a very low frequency. Mutagenic agents are important for they increase the mutation rate and provide a supply of new variability for selection. However mutations occur at random and beneficial mutants occur infrequently. Hence although we have new and valuable tools for plant improvement they must be used in conjunction with other special techniques to gain the utmost benefit.

Mutagenic Agents

Mutagenic agents produce both hereditary and non-hereditary changes in the cells of the treated organism. The hereditary changes, mutations, are largely deleterious but the advantageous mutant can be selected and used. The non-hereditary changes, physiological upsets, are also largely deleterious and tend to kill the organism. The mutation rate is proportional to the dose of the mutagen, hence the highest yield of mutations is reached at the highest tolerance level for the irradiated material. Consequently factors affecting tolerance are of importance and a knowledge of the biological action of the different mutagens is important in this respect.

A number of mutagenic agents are known and foremost among these are the ionizing radiations, ultra-violet radiations and certain chemicals.

(*i*) *Ionizing Radiations*

The ionizing radiations either consist of, or produce in the cell, charged particles of high kinetic energy. Their biological effect results from the transfer

TABLE I

Mass and charge of different particles (*Ehrenberg* 1954)

Particle	*Mass*	*Charge*
electron (β rays)	1	—1
	1800	
positron (β + rays)	1	+1
	1800	
proton (H ion)	1	+1
deuteron (H^2 ion)	2	+1
triton (H^3 ion)	3	+1
α particle (He ion) (α-rays)	4	+2
Li^7 nucleus	7	+3
neutron	1	0

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of this energy to the cell either by collision or by ionization of cellular components—which results in a chain of chemical reactions.

The radiations which consist of charged particles have low penetration and their uses for plant and animal material are limited. The charged particles are either electrons, e.g. β-rays produced by radioactive phosphorus (P^{32}); or atomic nuclei, e.g. α-rays produced by the decay of radon or polonium.

The radiations which produce charged particles in the cell are the electromagnetic radiations (X- and γ-rays) which produce electrons, and neutrons which produce atomic nuclei (protons). These have high penetrating power and consequently widespread use in biological experiments.

X-rays are readily available in a range of energies from commercial machines where they are produced by bombarding a target with electrons. Radioactive cobalt (Co^{60}) provides the most widely used source of γ-rays in plant improvement work. X- and γ-rays are the same type of radiation although differing in energy and consequently penetrating power (γ-rays from Co^{60} are more penetrating than

TABLE II

Ionizing radiations (Adapted from Ehrenberg 1954)

Radiation	Produced by	Ionizing particle: Type	Ionizing particle: Energy Max. Mev	Ionizing particle: Energy Av. Mev	Range in tissue Max. μ	Range in tissue Av. μ	Ion density ion pairs/μ tissue
(1) *Radiations consisting of charged particles*							
β rays	P 32	Electron	1.71	0.69	8,100	2,600	8
	S 35	„	0.17	0.05	340	55	31
	H 3	„	0.02	0.006	7	0.8	200
β + rays and γ rays	Na 22	Positron γ rays	0.57 (electrons from γ as a rule negligible)	0.22	2,000	520	13
Fast electrons	Acceleration in synchrotron		10 or more		30,000		10
α rays	Polonium 210	He ion	5.3		40		4500
	Radon	„	ca. 6.0		ca. 50		3700
(2) *Radiations producing charged particles in the cell*							
X rays (175 Kv.)	Roentgen apparatus	Electrons	0.175	0.01	370	3.5	105
γ-rays	Co 60	„	1.30	0.60	6,000	2,200	8
	Cs 137	„	0.66		2,500		
	Radium	„	2.2	0.5	10,000	1,700	9
Neutrons— Fast		Proton (H ion)	ca. 8	ca. 2	813	73	ca. 800
Thermal		„	0.56		8		2300
ex. Pile		„	ca.1.3		ca. 35		1300

X-rays) but both have high penetration compared with β- or α-rays. X- and γ-rays are used to radiate either seeds or vegetative parts of the plant and the dose can be delivered either over a short period (acute irradiation; dose rate 100 to 1000 r per *minute*) or, by growing plants close to a continuous source of radiation, for example Co^{60}, spread over the growing period of the plant (chronic irradiation; dose rate 0.08 r to 2000 r per *day*). Such differences in technique can be important, for the genetic effect depends on the total dose received whereas the physiological effect is influenced by the rate at which the dose is received.

Neutrons for biological experiments can be produced in small quantities by nuclear reactions, e.g. bombarding beryllium or tritium with deuterons, or in large quantities from nuclear reactors.

The different ionizing radiations differ in the pattern of ionization they produce in the cell and this difference is associated with their biological effect. Neutrons and α particles (high ion density radiations) produce ionizations in dense clusters whereas X, γ- and β-rays (low ion density radiations) produce scattered ionizations. Compared on the basis of total dose (ionizations per unit volume) the high ion density radiations produce more genetic changes than the low ion density radiations. In addition to this quantitative difference there are differences in the types of changes to both the genetic and physiological systems produced by the different radiations.

There are also differences in sensitivity to damage between different genera and species, genotypes, tissues, stages of cell division and genes. In general species with large and few chromosomes are the more sensitive, seeds are less sensitive than vegetative tissue and dividing cells more sensitive than non-dividing cells. The sensitivity can be influenced by environmental conditions, e.g. water content, gaseous atmosphere, etc.

(ii) Ultra-violet

Ultra-violet radiations for biological experiments are obtained from a mercury lamp or from a quartz mercury arc in conjunction with a monochromator. U.v. radiations are of much longer wave length than X-rays (u.v. 3900A to 1800A c.f. X-rays 5A to 0.05A) and consequently have little penetrating power, hence their biological use is very restricted.

Their biological action is by excitation and not ionization, the energy from the u.v. being absorbed by specific substances in the cell.

(iii) Chemicals

The mutagenic activity of formaldehyde was established by Rapoport (1946) and of mustard gas by Auerbach and Robson (1947). These discoveries stimulated a search for further chemical mutagens. The list of active substances is now long and diverse (Demerec *et al.* 1951; Fahmy and Fahmy 1956). It includes simple inorganic substances: boric acid, ammonia, hydrogen peroxide, copper sulphate and manganous chloride; simple organic compounds: formaldehyde, phenol and urethane; and complex organic substances: nitrogen mustards, imines, epoxides, sulphonates, purines and purine derivatives.

The chemical mutagens act by disrupting molecules in the cell with the specificity and mode of action of the different mutagens varying greatly. Some of these chemicals produce a different spectrum of mutants to those occurring spontaneously or produced by ionizing radiations (Fahmy and Fahmy 1956; Gustaffson and MacKey 1948). Consequently they may be of great use for producing new mutations in agricultural plants if the problems of penetration can be successfully overcome.

Genetic Changes and Techniques

The inherited characters of all organisms are determined by the genes which are carried on the chromosomes. A gene can exist in more than one form (allele), e.g. a gene for flower colour can exist

TABLE III

Detection of mutation after irradiation of pollen

Mutation	Dominant (A) to recessive (a)								Recessive (a) to dominant (A)							
Parent plant	AA								aa							
X1 seed	Aa								aA							
X1 phenotype	Non mutant (—)								Non mutant (—) with mutant sector (+)							
X1 gametes	A.a								a.A							
Fertilization	*Self*					*Cross*			*Self*					*Cross*		
X2 seed	AA		Aa		aa	AA		Aa	aa		aA		AA	aa		aA
X2 phenotype	—		—		+	—		—	—		+		+	—		+
X2 gametes	A		A.a		a	A		A.a	a		a.A		A	a		a.A
X3 seeds	AA	AA	Aa	aa	aa	AA	AA	Aa	aa	aa	Aa	AA	AA	aa	aa	aA
X3 phenotype	—	—	—	+	+	—	—	—	—	—	+	+	+	—	—	+

Cross fertilization means fertilization with non mutant gamete.

as an allele determining red flower colour or one determining white flower colour. The gene is said to mutate when it changes to a different allele.

The germ cells carry only one allele of each gene but the body cells carry two alleles (one from each parent). An organism with two identical alleles is homozygous for that particular gene; one with different alleles is heterozygous. Recessive alleles (*a*) only produce an effect on the organism when they are homozygous (*aa*); dominant alleles express their effect when either homozygous (*AA*) or heterozygous (*Aa*).

A mutation from the recessive to the dominant allele (*aa* → *Aa*) can thus be detected in the first generation after treatment. In the second generation 75 per cent. of the plants will be mutant (*AA* and *Aa*) after self pollination or 50 per cent. after cross pollination (*Aa*).

A mutation from the dominant to the recessive allele (*AA* → *Aa*) will not be expressed in the first generation after treatment, except for the extraordinarily rare occurrence of both genes in the cell being simultaneously mutated (*AA* → *aa*). However, after self pollination of these plants (*Aa* x *Aa*) 25 per cent. mutant plants (*aa*) will appear. If self pollination is not possible, crossing of heterozygous sister plants (*Aa* x *Aa*) in the second generation after treatment will result in 25 per cent. mutant plants in the third generation.

Thus selection for dominant mutants can be made in the first generation after treatment but recessive mutants cannot be detected until the second or third generation.

The frequencies of mutant plants referred to above relate to the progeny from the irradiated cell. If treatment is applied to the germ cells (pollen or egg) the mutant gene will be in all cells of the first generation plant.

However if treatment is applied to seeds or growing plants a particular mutation can only be expected to occur in one cell, hence only the progeny from this cell will carry the mutation. Thus the ratio of mutant to non mutant plants appearing in subsequent generations will depend on the nature of the genetic change (*A* → *a* or *a* → *A*), the type of pollination (cross or self) and the size of the sector carrying the mutation in the first generation plant.

In addition to the true gene mutations, mutant plants can occur as the result of chromosomal changes. Ionizing radiations and the other mutagens can break the chromosomes which are then capable of rejoining. During the breaking and rejoining pieces of chromosome can be lost (deletions) or reunion may occur in such a way that the new arrangement is different from the old (inversions and translocations). As with gene mutations most of the chromosomal changes are deleterious but when advantageous changes occur they are detected in the same way as gene mutations.

Practical Achievements and Research in Progress

The best examples of the successful induction of useful mutants are to be found in microorganisms. This is not surprising for here large numbers of treated cells can be quickly screened for mutation and the desirable mutant once selected can be asexually propagated.

During World War II the great increase in penicillin production was due in part to improved culture methods but the major increases in production came from the selection of high yielding strains of *Penicillium*. Selections from naturally

TABLE IV

Expression of mutation in first and second generation after treatment of pollen, seed and vegetative tissue

Material irradiated	Mutation to	First generation after treatment: Parental genotype	Genotype	Mutant expression	Second generation after treatment: Self fertilization: Genotype	Mutant	Cross fertilizaton: Genotype	Mutant expression
Pollen	Dominant	*aa*	aA	+	aa	—	aa	—
					aA	+	aA	+
					AA	+		
	Recessive	*AA*	Aa	—	AA	—	AA	—
					Aa	—	Aa	—
					aa	+		
Seed	Dominant	*aa*	*aa*/aA	—/+ (chimera)	*aa*/aa	—	*aa*/aa	—
					aA	+	aA	+
					AA	+		
	Recessive	*AA*	*AA*/Aa	—	*AA*/AA	—	*AA*/AA	—
					Aa	—	Aa	—
					aa	+		
Vegetative parts	Recessive	AA	*AA*/Aa	—	Sexual reproduction as for seed. Vegetative propagation of mutant sectors.			
		Aa	*Aa*/aa	—/+ (chimera)				
	Dominant	*aa*	*aa*/aA	—/+ (chimera)				

Cross fertilization means fertilization with non-mutant gamete.

TABLE V

Useful mutations induced by radiation

Plant	*Mutants*	*Reference*
I. Self-fertilizing		
A. *Diploids*		
Barley	Dense spike, large grain, broad leaf, tall and short plants, early and late flowering, straw stiffness, higher yield. Improved malting quality. Higher protein content for feed barley.	Gustaffson 1947, 1954 Shebeski & Lawrence 1954
Peas	"Stralart" variety. Increased yield, more branches, more pods, later maturity Gigas mutants.	Gelen 1955
Soy bean	Early ripening Inc. yield, shortened internodes, increased branching; more pods, inc. seed weight, earliness.	Gustaffson 1947 Zacharias 1956
Beans	"Schafer's Universal" variety. Inc. yield.	Gustaffson 1954
„ (Navy)	Bush type, earlier. Parent of "Sanilac" variety	Down & Andersen 1956
Sweet Lupins	Earliness.	Tedin 1954
Flax	Straw colour, inc. yield of long fibre.	Gustaffson 1947, 1954
	Rust resistance.	Konzak (unpub.)
Vetch	"Vitality mutant"—Later maturing.	Gelin 1954
Rice	Short straw (only top internode elongates).	Shapiro (unpub.)
Jute	Increased fibre yield and quality.	Chakraverti (1954)
Sesame	Increased yield of fruit and seed Earlier flowering Lower peroxide value of oil. (better keeping quality)	Chandhuri & Das (1954)
B. *Polyploids*		
Wheat	Res. to black stem rust Inc. yield, early and late maturity. Straw stiffness, inc. grain weight, inc. tillering, baking quality.	MacKey 1954
	Res. to leaf rust (transfer from Aegilops).	Sears 1955

Plant	*Mutants*	*Reference*
Oats	Inc. yield, early and late maturity. Straw stiffness, inc. grain weight.	Mackey 1954
	Rust resistance: increased quality. Victoria blight resistance Winter hardiness.	Konzak 1954, Frey 1955
Peanuts	Inc. yield and disease resistance.	Gregory 1955
II. *Cross-fertilizing*		
Oil turnip (B. rapa.)	Earliness, faster seedling growth Inc. yield	Gustaffson 1947
Spring rape (B. napus v. oleifera)	"Regina vårraps II" variety.	Gustaffson 1954
White mustard	"Primex" variety. Inc. yield and oil content.	Anderson & Olsen 1954
III. *Vegetatively propagated*		
Apples	Colour mutant (red)	Granhall, 1954
Pears	Colour mutant—striped, russeted.	Granhall, 1954
Black Currant (Ribes nigrum)	Increased vigour, shorter internodes.	Bauer (1956)
	Elongated clusters, larger fruit weight.	
	Moderate resistance to *Cronartium ribicola.*	
Poa pratensis	Resistance to rust and mildew. Longer leaves, larger tufts.	Julen G. (1954)
Carnations	Flower colour mutants.	Richter & Singleton 1955

occurring mutants increased yields of penicillin to 200 to 250 units per millilitre of culture selection (Raper 1946) but after these strains were treated with X-rays and ultra-violet radiations strains yielding up to 3000 units per millilitre were selected. Radiations have also been used to induce mutants yielding an increased proportion of the more effective penicillin X and less penicillin G.

Similarly, induced mutants of *Streptomyces griseus* with increased streptomycin production (Savage 1949), and of *Aspergillus terrens* with increased production of itaconic acid (an important base for certain plastics) (Hollander 1945) have been produced.

The achievements in higher plants have not been as striking as those for microorganisms. Selection and testing of the mutants is more laborious and time consuming and as we have seen it is more difficult to locate and use mutants in sexually reproducing organisms than in those reproducing asexually (vegetative propagation). However a number of significant advances have been made in Sweden, Germany, India and the U.S.A. —See Table V.

(*i*) *Research in U.S.A.*

Although the initial discovery that X-rays will induce mutations was made in the U.S.A. in 1927 few efforts were made to extend this technique to plant improvement until recent years. However over the last decade a large and comprehensive programme has been developed.

The extent of the work now in progress can be gauged from the Brookhaven radiation mutation programme. The Brookhaven National Laboratory in addition to having an active research programme in this field, has since 1952 provided radiation facilities for a number of universities and agricultural experiment stations in the U.S.A. They have this year generously extended these facilities to scientists of countries other than the U.S.A. Already this programme involves some 120 scientists from more than 60 diffierent institutions who are searching for mutations in more than 70 crops. In addition to the Brookhaven programme a number of workers have their own radiation facilities or use those at the Oak Ridge National Laboratory or other Atomic Energy Commission laboratories. Another cooperative programme, the University of Tennessee-Atomic Energy Commission Agricultural Research Programme which has been operating at Oak Ridge, so far entirely on animals, for seven years is now being extended to plants. This will provide facilities for the plant workers in the southern parts of the U.S.A.

Much of the work in progress is still in its early stages but preliminary reports from a number of workers indicate that potentially valuable mutations have been produced by the use of radiations. In my opinion the two most promising current fields are the selection of disease resistant mutants in cereals and the selection of higher yielding mutants in peanuts.

Frey (1954, 1955) and Konzak (1954) were both able to select mutants from the progeny of irradiated oat seeds which were resistant to stem rust. Because of their disease resistance these mutant plants are capable of giving increased yields. In this type of work the disease is used as a highly efficient positive screening mechanism and it permits easy detection of the desirable mutant. Sears (1955) has used this efficient screening mechanism to transfer resistance to leaf rust from the genus *Aegilops* to wheat. This work differs from that of Frey and Konzak for here disease resistance is not the result of a gene mutation but the delicate transfer of a piece of chromosome from one genus to another. Research is being undertaken to induce and to transfer disease resistance in a number of other crop plants in the U.S.A.

The selection of higher yielding peanuts by Gregory (1955) represents a very major contribution to this field of research—Dr. Gregory had for a number of years used conventional hybridization techniques in his peanut improvement programme. He was impressed by the increased variability in the progenies of irradiated peanut seeds when screened for reaction to two diseases, so commenced experiments to utilize this general increase in variability by selecting for increased yield. Significant yield increases have been obtained and in a shorter time than required for equivalent increases by conventional hybridization techniques.

It would be impracticable to discuss here all of the research aimed at selecting beneficial mutations from irradiated seeds. Much of this work is promising although in its early stages and it will certainly result in a valuable supplement to the store of genetic variability to be used either directly by release as commercial varieties or indirectly as parental material in conventional plant breeding programmes. An example of the latter is the utilization of an X-ray induced early flowering bush type of navy bean as one parent of the new variety Sanilac (Down and Andersen 1956).

Work with γ-rays at Brookhaven National Laboratory with corn (Singleton 1954), carnations (Richter and Singleton 1955) and a number of other plants has shown that mutations can be induced in growing plants when they are continuously irradiated. This type of treatment has great potential use for the induction of mutations in plants which can be vegetatively propagated and which

are either extremely heterozygous or have long generation times (i.e. woody trees and shrubs). A number of potentially valuable colour mutants have been located in flowers and fruit trees and testting of material subjected to chronic irradiation is being carried out at a number of research institutes.

(ii) Research in Sweden

Contrary to the situation in the U.S.A., research in this field has been actively pursued in Sweden since the discovery of the mutagenic nature of X-rays. This has been largely due to the drive of Professor Gustaffson who, as a student in 1928, commenced mutation work with agricultural crops. It is therefore to Sweden that we should perhaps look for the positive results to substantiate the promise of the present American research. It should be noted however that although the research has been conducted over a much longer period, at no time have there been as many workers in Sweden concentrating on this type of research as there are in the U.S.A. at present.

Significant advances have made in improving barley, wheat, oats, soybeans, lupins, flax and vetches and although no commercial varieties have been released in these crops the improved mutants are still being tested or are being used in plant breeding programmes. Commercial varieties of white mustard and summer rape have been released; and a variety of pea is being released this year. This work has demonstrated conclusively that advantageous mutants can be selected and that they can be of use both as varieties and as breeding material. However the results from Sweden do not fully confirm the promise suggested by the preliminary results from the U.S.A. It is perhaps significant that the two most promising lines of work in the U.S.A., disease resistance and increased yield in peanuts, are both concerned with physiological changes rather than morphological changes. Much of the Swedish work has been concerned with visible mutants, e.g. short straw, dense ear etc. Such mutants are of practical importance in Sweden and they are relatively easy to select, but they are unlikely to be as important as physiological mutants affecting characters not so readily observed in the field, e.g. yield or resistance to disease or drought.

Another most significant fact is that in Sweden "conventional breeding" of agricultural crops is highly advanced and such plants are closer to the physiological ceiling and consequently are more difficult to improve than, for example, peanuts grown in North Carolina which are a relatively new and ill adapted crop. This approach could be of great significance in Australia where all of our important agricultural plants are relatively recent introductions and few have been subjected to intensive plant breeding.

In addition to the practical results of the Swedish work some important theoretical points have been investigated. A comparison between diploids and tetraploids indicate that there is a greater chance of producing useful mutations in polyploids than in diploids. There is a higher observed mutation rate in the polyploids and the mutant forms are less extreme (MacKey 1954). The polyploids are better buffered against change than the diploids.

A comparison of the types of mutations produced by X-rays, neutrons and some chemical mutagens (Nybom 1956; MacKey 1956) indicates that different spectra of mutants are produced by the different mutagenic agents. This work could have wide practical significance if the agriculturally desirable mutants are produced with differing frequencies by different mutagens.

It is interesting that two of the three commercial varieties selected from X-ray treated material are in cross fertilizing plants. The selection of mutants in cross fertilizing species is more difficult than in self fertilizing species (Table III and IV)

and the establishment of the origin of new forms as induced mutants rather than the results of cross pollination is never absolutely certain. However this latter point seems to have been answered satisfactorily in that the characters selected had not been observed in unirradiated progeny.

(ii) Research in Other Continental Countries

In Germany a variety of beans "Schafer's Universal" resulting from irradiated material has been released and a considerable amount of work is in progress on selecting mutants of soybeans and black currants. The work with black currants is interesting in that a new selection technique is being used (Bauer 1956). Vegetative tissue is irradiated and as the buds develop from the irradiated stems the shoots are removed and any mutants are propagated vegetatively. Each year all shoots are removed from the irradiated plants and fresh buds develop from previously dormant cells. In this way a greater number of irradiated cells can be examined for mutations and a much higher yield of mutants obtained.

(iv) Research in England

Compared with U.S.A. and Sweden there is little effort being devoted to the selection of useful mutants in agricultural crops in England. However the research with certain chemical mutagens on *Drosophila* at the Chester Beatty Research Institute may have far reaching practical consequences. Some of these chemical mutagens have been shown to produce a different spectrum of mutants from those observed after treatment with ionizing radiations (Fahmy and Fahmy 1956). This together with the Swedish work indicates that some of the chemical mutagens may well provide a valuable adjunct to the ionizing radiations if the techniques of applying them can be satisfactorily solved.

General Conclusions

It is my opinion that ionizing radiations and other mutagenic agents have a definite role to play in the future of plant improvement. However this technique will be used in conjunction with the other techniques of plant improvement (hybridization, polyploidy, selection etc.) and will supplement rather than replace existing methods. It is already apparent that certain problems are suited to this type of approach but in many cases the information upon which to base a choice between the alternative methods of plant improvement is not available.

There is an urgent need for more information on the mode of action of the different mutagenic agents and the ways in which the various facets of their biological activity can be modified and directed. It is only through information of this kind that the mutation process can be changed from a random to a directed event. The work with chemical mutagens point the way to a more specific control of mutation and comparative studies using different mutagens add to the store of knowledge as well as providing a wider spectrum of mutants from which to select those beneficial to man.

The different ionizing radiations differ in their penetration, biological efficiency and to some extent in the spectrum of mutants they produce. X-rays and γ-rays have similar biological effects and the choice between them rests largely upon availability of equipment. An X-ray machine has greater flexibility than a Co^{60} source but it has more maintenance and dosimetery problems. But X- and γ-rays differ from neutrons in their mode of action, relative biological efficiency, the way in which their physiological effect can be modified by environmental conditions and in their mutation spectrum (Ehrenberg *et al.* 1955). β-rays and α-rays both have such low penetrating power that their use is limited. It is not possible at the present time to define the type of radiation or the environmental conditions which will produce the greatest yield of beneficial mutations. Comparative studies of this nature are being

actively pursued both in U.S.A. and Sweden.

Ultra-violet radiations and chemical mutagens have different modes of action in the cell and there is evidence of a markedly different mutation spectrum following the use of certain chemical mutagens. Both of these mutagens present problems of penetration and as a consequence of this ultra-violet radiations can only conveniently be used for radiation of pollen. The problems of penetration of the chemical mutagens is being tackled by taking normal components of cells (e.g. amino acids) and making them mutagenic by the addition of active groups (e.g. nitrogen mustard).

Although we have, as yet, little control over the process of mutation the biological result can be greatly influenced by manipulation of the environment, choice of the material to be treated and the selection techniques used. Variations in the water content of seeds or the gaseous environment (oxygen content etc.) and metabolic activity of cells is known to alter both the physiological and chromosomal changes which occur after X-raying. Whether it differentially affects gene mutation is not yet known.

The success of any attempts at plant improvement will be greatly influenced by the selection of plant material. The type of plant tissue to be treated depends upon the type of mutation desired, the reproductive system of the plant and the selection technique to be used. More important still is the selection of the species to be improved. The induction of mutations provides the plant with a fresh burst of variability, but it is not always lack of variability which is the restrictive factor in plant improvement. In some species, particularly those that cross-fertilize, the restrictive factor is not variability but lack of adequate selection techniques. The provision of more variability in such a plant does little to improve the situation. However even in such species there may be a lack of a particular character (e.g. disease resistance) and in this case the induction of mutations is justified.

Because of the greater natural variability and the difficulties of detecting recessive mutants in cross-fertilizing species most of the research on induced mutations for plant improvement is being done on self-fertilizing species. However the evolution of these has largely progressed through the accumulation of spontaneous mutations whereas cross-fertilizing species have used variability from not only spontaneous mutations but also recombinations (resulting from hybridization) in their evolutionary processes. It could be argued therefore that improvement could best be effected in self-fertilizing species by permitting more recombinants (hybridization) and in cross-fertilizing species by inducing more mutations. It is perhaps significant in this respect that the first two commercial varieties which resulted from mutation breeding in Sweden were both in cross-fertilizing plants (mustard and rape).

As the processes of evolution result in the adaptation of plants to particular ecological niches, any change in the environment, e.g., domestication and cultivation, necessitates readaptation. New crops in new areas would require the most readaptation. As already mentioned this could largely account for the dearth of practical achievements from Sweden and the success in improving peanuts in North Carolina. It also augurs well for the success of similar ventures with such crops as subterranean clover in Australia.

In addition to these rather general considerations the technique has a number of special uses. The induction of specific mutations in vegetatively propagated plants which are often extremely heterozygous and have long reproductive cycles appears more promising than conventional plant breeding. Similarly the technique is promising where varieties lack a particular desirable characteristic and in flowers and other ornamentals where the unusual mutant is of commercial value.

It has many uses as a supplement to plant breeding, for example, to aid in the transfer of valuable genes between species and genera, to split close linkages, to change breeding systems by inducing sexual reproduction in apomicts.

Until some direction of the mutation process can be achieved much attention must be devoted to selection techniques. Where specific changes in well adapted genotypes are required positive selection and aids such as host-parasite or host-symbiant reaction are of obvious importtance. Where readaptation is being attempted the use of natural selection is necessary.

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PHOSPHATE LEVEL IN THE SUBSTRATE AND DIFFERENT DAY AND NIGHT TEMPERATURES IN RELATION TO THE GROWTH OF FLAX

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Summary

A water culture experiment is described in which flax was grown at each combination of two day temperatures (20° and 26°C.), two night temperatures (14° and 20°C.) and two levels of phosphate in the solution.

Height of main stem was increased by high day temperature and reduced by high phosphate, whereas these variables had reversed effects on tillering (both mean number and total length per plant). However, high phosphate improved tillering when the day temperature was 20°C., but not when it was 26°C. High phosphate also increased total length of tillers when the night temperature was 20°C., but not when it was 14°C.

Total growth (top + roots) was reduced by increases in either day temperature or phosphate, but there were differential effects on tops and roots.

An inverse relationship occurred between day and night temperatures with respect to their effect on total growth and height of the main stem, but only where the day temperature was unfavourable for total growth. Thus, night temperature was unimportant when the day temperature was low (20°C.), but at the high day temperature (26°C.) the plants grew best at the low night temperature (14°C.).

Introduction

The present experiment was designed to obtain information on the effects of variable day and night temperatures on the growth of flax, and further, to determine whether any interaction occurred between phosphate level in the substrate and the response of this plant to temperature.

The experiment was conducted in Earhart Plant Research Laboratory of California Institute of Technology.

Method

The plants were grown in water cultures each pot containing 900 ml. of solution, in which four plants of flax (variety Liral Crown) were grown. The seedlings were germinated in acid treated washed sand and were transferred to the cultures as soon as they could be conveniently handled.

The composition of the nutrient solution was based on that of Arnon (1938) except for the following modifications with respect to phosphate additions:—

Low Phosphate (P_1) 2 drops KH_2PO_4 $\frac{M}{1}$ per pot.

High Phosphate (P_2) 1 ml each of KH_2PO_4 $\frac{M}{1}$ and NaH_2PO_4 $\frac{M}{1}$ per pot.

Fresh nutrients were added to each pot after three weeks, but the P_2 treatment at this stage received only 1 ml KH_2PO_4 $\frac{M}{1}$ per pot.

Four combinations of day and night temperature were employed as follows:—

Day	Night
20°C	14°C
20°C	20°C
26°C	14°C
26°C	20°C

The plants received eight hours' natural daylight in the greenhouse supplemented by 8 hours' artificial light of an

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intensity of 1100 foot candles. The techniques used at Earhart Plant Research Laboratory for the control of day and night temperatures, photoperiod and light intensity have been described by Went (1950a).

Each treatment was replicated eight times. Immediately prior to the termination of the experiment on day 50, the mean height (cms) of the main stem, and mean number and total length (cms) of tillers per plant was recorded for each pot. Roots and tops were harvested separately, dried at 70°C for 72 hours and weighed.

Results

(a) *Main Effects*

The main effects of day temperature, night temperature and phosphate level are set out in Table I. These may be summarised as follows:—

(i) *Day temperature*—Increase in day temperature from 20°C to 26°C had reverse effects on the height of the main stem (increased) and total weight and number and length of tillers per plant (decreased). The decrease in growth (dry weight) was relatively greater for roots than tops as the top/root ratio was increased.

(ii) *Night Temperature*—The effects of night temperature were not as important as day temperature over the range studied. An increase in night temperature from 14°C to 20°C had no effect on the mean height of the main stem, but depressed dry weight (tops relatively more than roots) and both number and total length of tillers.

(iii) *Phosphate*—Increase in phosphate to the P_2 level decreased total growth (tops more than roots) and height of the main stem, but increased both the numbers and total length of tillers.

(b) *Interactions*

The only significant interactions which occurred in this experiment are described below:—

(i) *Day temperature X night temperature*—Details of this interaction are set out in Table II.

TABLE I.

Main effects of day temperature, night temperature and phosphate level on the growth of flax in water cultures.

Treatment	Dry Weight*		Mean Height of Main Stems (cms)	Mean Number of Tillers per Plant	Mean Total Length of Tillers per Plant (cms)
	Top + Root	Top/Root			
Day Temp. 20°C	2.324	0.393	44.9	2.89	30.92
Day Temp. 26°C	2.012	0.543	57.2	1.76	12.08
Difference (26-20)	–0.312	0.150	12.3	–1.13	–18.84
Night Temp. 14°C	2.189	0.487	52.0	2.50	23.53
Night Temp. 20°C	2.147	0.449	50.0	2.14	19.47
Difference (20-14)	–0.042	–0.038	–2.0	–0.36	–4.06
P_1	2.201	0.509	53.4	2.08	19.38
P_2	2.135	0.427	48.7	2.57	23.62
Difference (P_2-P_1)	–0.066	–0.082	–4.7	0.49	4.24
Difference for Significance of individual differences					
5% level	0.035	0.020	2.51	0.26	2.88
1% level	0.046	0.027	3.36	0.35	3.86

*Data Transformed log (1000 X).

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TABLE II.

Day temperature X night temperature interaction.

Night Temperature	Dry Weight* Top + Root			Mean Height of Main Stem (cm)		
	Day Temperature		Difference (26-20)	Day Temperature		Difference (26-20)
	20°C	26°C		20°C	26°C	
14°C	2.315	2.063	−0.252	44.2	59.8	+15.6
20°C	2.334	1.959	−0.375	45.5	54.6	+9.1
Difference (20-14)	+0.019	−0.104	−0.123	+1.3	−5.2	−6.5

Differences for significance		Dry Weight	Mean Height of Main Stem
Individual differences in margins of table	(5%)	—	3.54
	(1%)	0.065	4.73
Between differences	(5%)	—	5.01
	(1%)	0.093	6.69

*Data Transformed log (1000 X).

At the lower day temperature (20°C) differences in the associated night temperature had insignificant effects on total growth (dry weight) or mean height of the main stem, but with high day temperature (26°C) the plants grew best at the low night temperature.

(ii) *Phosphate X day temperature*— The significant effects of this interaction are given in Table III.

Although there was no interaction effect of phosphate X day temperature on total growth (top + root), the reduction in the top/root ratio induced by increased phosphate was greater when the day temperature was 20°C than when it was 26°C.

The analysis of tops and roots separately given in Table IV show that, whereas increase in phosphate reduced the top

TABLE III.

Phosphate X day temperature interaction.

Phosphate Level	Top/root Ratio*			Mean Number Tillers per plant			Mean Total Length of Tillers (cm)		
	Day Temperature		Difference	Day Temperature		Difference	Day Temperature		Difference
	20°C	26°C	(26-20)	20°C	26°C	(26-20)	20°C	26°C	(26-20)
P_1	0.460	0.557	0.097	2.36	1.80	—0.56	26.56	12.18	—14.38
P_2	0.325	0.528	0.203	3.42	1.71	—1.71	35.26	11.97	—23.29
Difference (P_2-P_1)	—0.135	—0.029	+0.106	1.06	—0.09	—1.15	8.70	—0.21	—8.91

Differences for Significance		Top/Root	Mean Number of Tillers/Plant	Mean Total Length of Tillers
Individual Differences in Margins of Table	(5%)	0.029	0.037	4.06
	(1%)	0.038	0.049	5.44
Between Differences	(5%)	0.041	0.052	5.74
	(1%)	0.054	0.069	7.69

*Data Transformed log (1000 X)

weight of the plants equally at 20° and 26°C day temperatures, root weight was actually increased by higher phosphate at 20°C and reduced at 26°C day temperature. This differential effect on root growth accounts for the differences in top/root ratio referred to above.

TABLE IV.

Phosphate X day temperature interaction. Analysis of tops and roots separately.

Table of Differences (P_2-P_1)*

	Day temperature		Difference for Significance	
	20°C	26°C	5%	1%
Tops	–0.105	–0.109	—	0.048
Roots	+0.030	–0.080	0.026	0.035
Difference	0.135	0.029	0.029	0.038

*Data Transformed log (1000 X).

Although increased phosphate reduced the dry weight of the tops (Table IV) this treatment improved tillering (Table III). This increase in tillering was evidently not as important in its effect on dry weight as the reduction in height of the main stem which was also induced by added phosphate (Table I).

(iii) *Phosphate X night temperature*—As shown in Table V. the effect of phosphate on the mean total length of tillers per plant was dependent on night temperature.

TABLE V.

Phosphate X night temperature interaction.

Mean total length of tillers per plant (cm).

Phosphate level	Night Temperature 14°C	20°C
P_1	22.99	15.75
P_2	24.06	23.18
Difference (P_2-P_1)	1.07	7.42

	5%	1%
Difference for significance of individual differences	4.06	5.44

Increase in phosphate had no effect when the night temperature was 14°C, but caused a significant increase in total length of tillers with a night temperature of 20°C.

Discussion

This experiment has demonstrated that day and night temperatures affect the development of flax, and that these effects may be exerted differentially on different parts of the plant, e.g. main stem, tillers and roots.

The general validity of such effects has already been established on a range of plants, as indicated in the review of the literature by Went (1953). There are, however, certain aspects of the present results which warrant emphasis.

It has been shown that high day temperature (26°C) is the most important factor inducing elongation of the main stem in flax, and that low night temperature may have a lesser significant effect, but only when combined with the high day temperature. By contrast, length of tillers was enhanced by low day temperature, and here again the effect of low night temperature, although significant, was much less important. This is in contrast with the work of Went (1950b, 1953) with tomatoes, where it was found that night temperature was the importnat factor associated with stem elongation, whereas day temperature could vary within wider ranges without appreciable effect on this plant. It is evident, therefore, that the relative importance of day and night temperatures to the growth of plants varies between species.

There was an inverse relationship between day and night temperatures, whereby plants grown at a high day temperature (which depressed total growth of the plants), made best growth at the lower night temperature. On the other hand, at the lower day temperature, night temperature was unimportant. A somewhat similar relationship has been described by Campus and Went (1952)

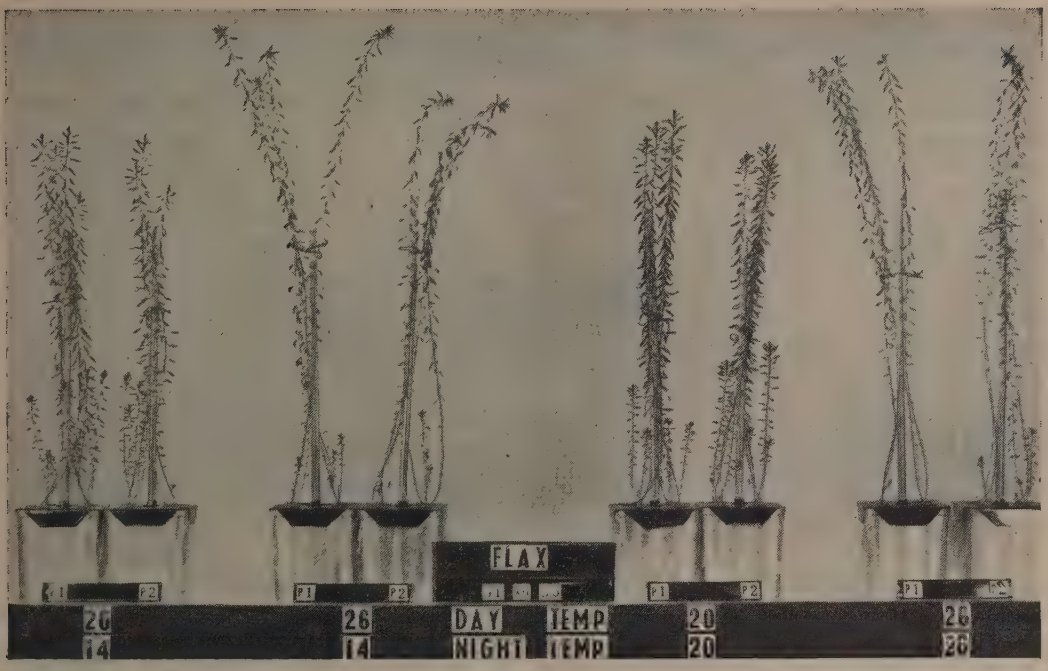

Figure 1.
Representative plants photographed on Day 45. The phosphate and temperature treatments were as indicated.

for the slow growing tobacco variety Cuba White. Where day temperature was optimum, the effect of night temperature was unimportant, but when day temperature was sub optimum, Cuba White grew best at a higher temperature. Millikan (unpublished data) has demonstrated an inverse relationship between day and night temperatures in relation to the growth of subterranean clover.

Age of plants may be an important factor in the response of tomatoes, chilli pepper and tobacco, to night temperature (Went 1953). The most striking example of this phenomenon occurred with chilli pepper (Dorland and Went 1947). Young plants grew best at a night temperature of at least 30°C, but as they became older, the optimum temperature decreased. Thus, at 27°C day temperature, the optimum night temperature in 108 day old plants was as low as 8.5°C. It is unknown whether age of the plant has any comparable effect on the response of flax to night temperature.

The results of the present experiment have shown that day and night temperatures significantly affect the response of flax to variation in the phosphate level in the substrate. There is little information available regarding the effect of temperature on phosphate uptake or utilization by plants, although this is obviously a very important subject, affecting as it does, the interpretation of the results of fertilizer experiments. The differences which may occur between the results of fertilizer trials with the same soil in the greenhouse and in the field may be attributable in part at least to variations in the temperatures under which the two types of experiments were conducted.

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BOOK REVIEWS

AGRICULTURAL ECOLOGY

By G. AZZI

(*Publishers*: *Constable and Co., London*, 1956. *No price shown.*)

This is an English translation of the book by Professor Azzi, Professor of Agricultural Ecology in the University of Perugia, who has been teaching this subject since 1920. From 1929 onwards he has helped in the establishment of such a course in the University of Buenos Aires, Argentina, and also in other countries.

His book is divided into 4 sections, (1) Agricultural Climatology, (2) Soil Units and Climate-Soil Complex, (3) Yield and Ecological Characteristics of Cultivated Plants, and (4) Factorial Combinations and Differential Analysis of Yield.

He is concerned with training the student to select the highest yielding variety of crop plant for any locality over a number of years, and so outlines measurements of physical environment, and of the plant's development, related most to yield.

His "new concepts" (see preface) are familiar. They comprise—

(1) "meteorological equivalents" (measures of such factors as temperature and rainfall in relation to the development of the plant and its yield, so that critical levels can be defined.)

(2) Soils in their relation to plant yield (through their chemical supply, water balance and workability).

(3) The plant character of "velocity—mass—structure," which is its length of growing season, yield and structure.

(4) Geographical trials of varieties of crop plants, world-wide if possible, to measure varietal response to environment.

(5) "Differential analysis" of yields of the one group of varieties in a range of environments to locate the importance of the various environmental factors affecting yield.

The book is well worth reading from several angles: (1) that of the relation (well documented) of climatic to crop growing seasons in countries other than ours, (2) that of the "world" view of a crop such as wheat, and (3) that of the interest of finding familiar problems under the cloak of peculiar phrases.

Y. AITKEN.

EFFECT OF SOIL EROSION ON PRODUCTION IN A MIXED FARMING AREA IN VICTORIA

By I. MOLNAR

The problems involved in the assessment of returns attributable to soil conservation works and measures were discussed by Molnar (1954). In Victoria, paucity of records for farms where conservation works were carried out on a large scale, limit the study of an erosion production relationship to farm surveys. For such surveys, in areas where serious erosion occurs, detailed soil and erosion maps are essential. These are available for only two areas in Victoria, namely around Dookie and Coleraine.

Molnar (1955) studied production in relation to erosion, pasture improvement and land values on 57 farms around Dookie, and the effect of erosion and land values around Coleraine. Also, the efficiency of dairy farming practices around Coleraine were discussed by Molnar (1956). The present paper deals with the production and erosion aspects of the Coleraine area.

Farmers were interviewed late in 1955 and early 1956 around Coleraine within the area of approximately 70 sq. miles covered by the soil and erosion maps of Blackburn and Leslie (1949) and in an adjoining area of 5.6 sq. miles mapped in 1956. Information was collected for the years 1954 and 1955. The distribution of the farms is shown in Table I.

The annual rainfall at Coleraine was 4½ inches below average in 1954 and average in 1955. The May-October rainfall was 3½ inches below average in 1954 and 1½ inches above average in 1955.

Some Features of the 49 Farms Used in the Investigation

Table II shows the size distribution of the farms and Table III the classification of the farms according to the type of farming enterprise. In Table IV the relative area of land under improved and native pastures and superphosphate usage on pastures are shown.

The area under cropping was negligible on most farms. Generally, cropping was confined to the production of oats but occasionally few acres of lucerne, rape, turnips and chou mollier were also grown on some farms.

The breeds of the animals varied with the farms. Corriedale ewes were kept on 19 farms, other wool breeds on 12, cross breeds on 8 and British breeds on 1. Corresponding figures for dairy cows were: Jersey on 17 farms and cross breeds on 9. The breeds of beef cows were: Hereford and cross breeds on 7 farms each, and Shorthorn on 1 farm.

Data Used and Method of Computation

(*i-ii*) *Soil and erosion classes.* As in the study of erosion and land values in this area by Molnar (1955), in the present investigation the soil types were grouped by the soil surveyor into six classes. The most fertile soil types were put in number 1 class and the final class for each farm was determined by computing the weighted average of the various classes. Then each farm, without regard to its soil class, was placed into one of five erosion classes, with number 1 class allotted to uneroded land. This classification was made according to the extent and degree of erosion (if any) on each property as a whole.

I. MOLNAR, Ph.D., M.Agr.Sc., is Conservation Economist with the Soil Conservation Authority of Victoria.

TABLE I.

Showing farms used in the investigation in relation to all farms.

	Square miles	Area of farms as per cent. of total area	Number of farms
Farms used in the investigation	30	48	49
Farms excluded from the investigation—			
(a) over 50 acres size	28	44	64
(b) under 50 acres size	5*	8*	N.A.
Total	63*	100*	N.A.

The reasons for the exclusion of 28 farms were as follows:
1. Part of the farm outside the area covered by soil and erosion maps, although 7 farms with some land outside this area and 4 farms adjoining it were included and subsequently mapped (20 farms, 8.1 sq. miles);
2. No adequate and/or reliable information could be provided by the farmer (13 farms, 7.1 sq. miles);
3. The area and/or management of the farm changed during 1954-55, or part of the farm was affected by bushfires of 1954 (23 farms, 5.7 sq. miles);
4. Considerable part of the farm was used for stud cattle breeding (1 farm, 5.0 sq. miles);
5. The farm was used predominantly for beef production (3 farms, 0.9 sq. miles);
6. Information was refused by the farmer (2 farms, 0.6 sq. miles);
7. The farmer acted as a dealer in livestock (2 farms, 0.6 sq. miles).
*These figures exclude areas burnt in the bushfires of 1954 (8.4 sq. miles) and the township of Coleraine (0.9 sq. miles), but include all reserves, e.g., roads, railways, etc.
N.A. = Not available.

(*iii*) *Rate of stocking per acre.* The 1954-1955 average rate of stocking was expressed as number of dry Merino sheep per acre. It was calculated from the number and types of stock and the date of stock movements on and off the farm. The units used for conversion were those calculated by Lang *et al.* (1952) and corrected for hand feeding and fodder conservation.

(*iv*) *Production.* The 1954-1955 average production per acre was calculated both as physical production and production in terms of money.

(A) Physical Production—

Wool production was adjusted for sales and purchases of sheep before shearing, but butterfat production was not adjusted for variations in the size of the herd during the year.

Butterfat production was measured by the butterfat deliveries made to the factories. In addition, all fodder hand fed, purchased or conserved was used for the adjustment of wool and butterfat production.

Livestock production was assessed differently for the various animals. The production of lambs and calves was taken as the numbers marked or reared. For other animals, the annual rate of stocking (calculated as described previously) was used as a guide to production. Actual production was assessed, however, as a fraction only of the calculated annual rate of stocking. The fraction used for denoting production was based on the economic life of the animals under local

TABLE II.

Size distribution of the farms.

Acres	No. of farms
50-99	2
100-199	16
200-299	14
300-399	2
400-499	5
500-599	3
600-699	3
1000-2500	4
	Total 49

TABLE III

Classification of farms according to enterprise.

Enterprise	Number of farms	Acres
Predominantly wool production with:—		
"Very high" sheep: cattle ratio*	4	2,690
"High" sheep: cattle ratio**	5	5,153
"Moderate" sheep: cattle ratio***	6	2,996
"Low" sheep: cattle ratio****	3	1,029
Dairy and wool production	10	2,118
Dairy production	9	1,903
Dairy, wool and fat lamb production	7	1,843
Wool and fat lamb production	5	1,211
Total	49	18,943

*Either sheep only, or 21.3—34.8 dry Merino sheep to 1 dry Merino sheep equivalent of cattle.
**9.5—17.8 dry Merino sheep to 1 dry Merino sheep equivalent of cattle.
***4.2—6.6 dry Merino sheep to 1 dry Merino sheep equivalent of cattle.
****3.3—3.5 dry Merino sheep to 1 dry Merino sheep equivalent of cattle.

farming conditions for ewes, wethers, weaners and cows. For other animals the fraction was determined with regard to the time involved in producing a relatively more valuable animal from a relatively less valuable one, namely heifers, vealers and steers from calves, and bullocks from steers. Thus the fraction of the computed annual rate of stocking used for the measurement of physical production (for animals other than lambs and calves) was as follows:

Ewes, wethers, weaners and dairy cows	1/6
Dairy heifers	1/2
Beef cows	1/10
Beef heifers, steers and vealers	2/3
Bullocks	2/5

(B) Production in Terms of Money—

The diversity of products made the conversion of the computed physical production into money necessary so as to

TABLE IV.

Showing number of farms by types of pasture (1954-1955 *av.*) *and superphosphate usage per acre* (1953-1955 *av.*) *of the total area under each pasture type.*

Percentage of farm area under:	0 %	<26 %	26-49 %	50-75 %	>75 %	Total farms
	Number of farms					
Improved pasture*	0	0	4	2	43	49
Native pasture	28	12	4	5	0	49
Superphosphate used per acre on:	**0 lb.**	**<40 lb.**	**40-80 lb.**	**81-120 lb.**	**>120 lb.**	**Total farms**
	Number of farms					
Improved pasture*	2	7	16	20	4	49
Native pasture	45	3	0	1	0	49

*Improved pasture was defined as pasture which, according to the farmer, contained substantial sub. clover and/or perennial rye grass in the sward.

enable a statistical analysis. The following 1953/54-1954/55 average prices were applied to the computed production, without considering differences either in the quality of the products or in the breeds of animals.

Wool price was the average for counts 60's to 56's derived from the counties of Dundas and Normanby: 79.44d. per lb.

Butterfat price, including Commonwealth subsidy, was: 55¼d. per lb.

Livestock prices were those obtained on the Coleraine market by farmers in or adjacent to the mapped area through sales by one of the major stock brokers. These prices were as follows: ewes £2.01, wethers and weaners £2.70, lambs £2.40, dairy cows and heifers £16.84, dairy steers £19.59, dairy calves £5.54, beef cows and heifers £25.08, beef steers and vealers £23.15, beef calves £15.50, bullocks £39.49.

TABLE V.

Showing value of production (1954-1955 *av. gross return per acre*) *by farming enterprise.*

Enterprise	£
Predominantly wool production with:—	
"Very high" sheep: cattle ratio*	7.12
"High" sheep: cattle ratio**	9.18
"Moderate" sheep: cattle ratio***	11.45
"Low" sheep: cattle ratio****	11.06
Dairy and wool production	12.42
Dairy production	12.10
Dairy, wool and fat lamb production	11.55
Wool and fat lamb production	9.30

*Either sheep only, or 21.3—34.8 dry Merino sheep to 1 dry Merino sheep equivalent of cattle.

**9.5—17.8 dry Merino sheep to 1 dry Merino sheep equivalent of cattle.

***4.2—6.6 dry Merino sheep to 1 dry Merino sheep equivalent of cattle.

****3.3—3.5 dry Merino sheep to 1 dry Merino

(*v*) *Production per stock unit* (1954-1955 av. dry Merino sheep equivalent) was also calculated.

(*vi-vii*) *Improved pastures and native pastures* (1954-1955 av.) were expressed as per cent. of the farm's area.

(*viii*) *Superphosphate usage on improved pasture* (1953-1955 av.) was calculated per acre of the total area of such pasture. As shown in Table IV, superphosphate was seldom used on native pasture and was, therefore, ignored.

(*ix*) *Area under crops* was generally negligible and this was also ignored.

Findings of the Statistical Analysis

For the purpose of statistical analysis the 49 farms were put into eight groups (shown in Table III) and all comparisons were restricted to within each group. This was done to eliminate errors because of the approximate nature of the conversion units used in the calculation of stocking rates and also to overcome differences arising from the type of farming in the value of production per acre. The average value of production is shown in Table V for each of the eight groups of farms.

A study was made of the relationships between value of production per acre (P), rate of stocking (SR), soil class (S) and erosion class (E). In addition to this study, value of production per acre was considered also in terms of production per stock unit (P/SK) and stocking rate (P/SR).

Because of the nature of the data, the production attributable to improved pasture and the production attributable to quantity of superphosphate application to such pasture were so small as to be of no statistical significance and were omitted from all calculations. On the overwhelming majority of the farms the bulk of the acreage was under improved pasture (see Table IV) and this fact is likely to explain the lack of statistically significant relationship between the area of improved pastures or native pastures and the value of production per acre. The lack of

significant relationship between quantity of superphosphate used on improved pasture and the value of production can probably be ascribed to the natural high fertility of many soils which often carry dense growth of perennial rye grass pastures as a "native" vegetation.

The findings of the statistical analysis* show that:

1. Erosion class and soil class are relatively independent, only 9.0 per cent. of the variation of erosion being due to soils.

2. The variation in the value of production per acre is associated with the adjustment of stocking rate to the productive capacity of the farm (in terms of soil class and erosion class) rather than with the production per animal.

3. Increase in soil class by one unit (i.e., decrease in fertility) results in a decrease in the value of production per acre of approximately £1.

4. Increase in erosion class by one unit results in a decrease in value of production per acre of approximately 14 shillings.

Discussion and Conclusion

The relative independence of soils and erosion can be attributed to the predominance of gullying and siltation types of erosion on the surveyed farms. It is claimed that many of these extremely large gullies around Coleraine were developed as a result of furrows ploughed along the drainage lines through several adjoining farms in the early days of settlement. Thus gullies, like the silting of river flats are the result of more than just localised conditions.

The findings of the statistical investigation indicate that farmers judge the productive capacity of their farms reasonably well and stock them accordingly. Variations in the quantity of wool produced per sheep, or butterfat per dairy animal and in the number of livestock per breeding animal are negligible on all farms.

Assuming that two-third of the differences in value of production are costs, and capitalizing the net return at say 4 per cent., it is found that the computed value of land attributable to a difference of one soil class is approximately £8 and to one erosion class approximately £6. However, in the study of the relationships between land values, soils and erosion in the same area during the 1939-1953 period based on actual land sales data, Molnar (1955) found that a difference of one soil class affected the actual price of the land by approximately £5 per acre and one erosion class by approximately £1½ per acre.**

In the Coleraine area prices paid by buyers of land have a much closer bearing on the productivity of land on account of variations in soils than on account of variations in erosion. While the effect of soils on productivity is about one and a

*$r_{SP} = -0.42$ $(P < 0.01)$	$r_{S(SR)} = -0.33$ $(P < 0.05)$	$r_{S(P/Sk)} = -0.11$ (n.s.)
$r_{EP} = -0.43$ $(P < 0.01)$	$r_{E(SR)} = -0.32$ $(P < 0.05)$	$r_{E(P/Sk)} = -0.19$ (n.s.)
	$r_{ES} = 0.30$ $(P = 0.05)$	

Partial reg. coeff. of P on E = —0.6830 ($P < 0.05$) ± 0.5781 95% confidence interv.
Partial reg. coeff. of P on S = —1.0754 ($P < 0.05$) ± 0.9563 95% confidence interv.

**The validity of the investigation of land values is not likely to be affected by the prices paid for land during the period of land sale control, between February, 1942, and September, 1949, when land sales had to be made at prices prevailing on 14th February, 1942, because the aim was to determine the *difference* in the prices paid in any one year for areas of land which had been eroded to varying degrees, and not the actual price paid. The possibility of an error arising from changes over that period in the recognition of erosion by buyers is likely to be negligible.

half times as great as the figure attributed to them by buyers of land, the effect of erosion is four times as great. Even with regard to soils, the difference is such that it could hardly be ascribed purely to variations in the profitability of production between the years 1954-1955 and the period used for the study of land values. With regard to erosion, however, the magnitude of the difference precludes any such possibility. Farmers in the Coleraine area do not pay adequate attention to erosion when buying land even when it is quite obvious if not spectacular.

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BOOK REVIEWS

APPLIED ANIMAL NUTRITION: THE USE OF FEEDINGSTUFFS IN THE FORMULATION OF LIVESTOCK RATIONS

By E. W. CRAMPTON

(*W. H. Freeman and Company, San Francisco*, 1956. 458 *pages*. $6.50.)

The book is written in four sections—
(1) What Are Feedstuffs.
(2) Nutritional Requirements of Animals.
(3) The Nutritional Characteristics of Some Common Feeds, and
(4) Ration Formulation.

The author has used modern style by asking questions and answering them by discussion. The volume deals with some phases of animal nutrition which receive brief mention in other volumes on this subject. For instance, a chapter is devoted to a critical examination of the naming of foods and the terms and definitions used by the stock food industry. "The Proximate Analysis of Feeds" is the heading of the second chapter where the standard analysis of stock foods is critically discussed.

In the last section it is shown that the feed formulation industry was one of the top ten of the nation (Canada) in 1954.

The hand feeding of swine, dairy and beef cattle are dealt with under Canadian conditions. Only the briefest mention is made of pastures and grazing.

Canadian legislation concerning the control of feedstuffs is summarised in one of the appendices.

A. C. T. HEWITT.

A SYSTEM FOR ASSESSING THE CLEAN SCOURED YIELD OF AUSTRALIAN GREASY WOOL

By S. S. Y. YOUNG and R. E. CHAPMAN

Summary

A system for assessing the clean scoured yield of Australian greasy wool is presented. This system is based on a relation between the commercial count and the average clean scoured yield of greasy wool of fixed descriptions. Simple adjustments are made for other wools.

An experiment to test this system was carried out in which four observers, inexperienced in yield assessment, made repeat estimations on 53 greasy wool samples. The mean deviations from the laboratory yields of the yields assessed by the observers ranged from zero to — 4 per cent. with standard deviation of difference of the order of 4 per cent. The overall repeatability of the observers was reasonably high. Analysis of the data showed that the first order interactions involving observers and styles of wool, and observers and fleeces were significant. All interactions involving repeats were non-significant.

Introduction

With the advent of fleece measurements in the study of various problems of sheep and wool production, and as an aid in the selection of sheep, the determination of clean fleece weights is important (Moule, Chapman and Beattie 1954; Riches and Turner 1955; Anon. 1955). These clean fleece weights can be calculated from greasy fleece weights and the yields of representative samples of the fleeces.

Wool metrology laboratories have, and are, being established for the analysis of fleece characters. However, it is possible that these facilities may not be available at a particular time when yield determinations are required. In these circumstances, or when precise information of yield is not necesary, e.g., ewe selection, it would be advantageous if a visual method of assessing yield with reasonable accuracy were available. Such knowledge would be of obvious benefit to many graziers, research workers and students of sheep husbandry and wool technology.

The clean scoured yield of greasy wool may be defined as the ratio, expressed as a percentage, of the weight of the clean wool, with a 16 per cent. regain of moisture, to the original weight of the greasy wool; thus the weight of the clean wool is calculated as 116 per cent. of its dry weight. The yield, therefore, depends on the amount of wax, suint, dirt, vegetable matter and excess moisture. The proportions of these components can vary within wide ranges. Analyses of greasy wool in the Sheep Biology Laboratory have shown that it is possible for the wax to comprise as high as 35 per cent. of the greasy wool weight, and the suint up to 15 per cent. Dirt contents of up to 40 per cent. are not unknown, and the vegetable matter content may be 12 per cent. or more. The moisture content of greasy wool may be as high as 20 per cent., a range of 8-16 per cent. having been found in wools from New South Wales (Young 1955).

Because the yield of wool is so variable, it normally takes several years for a person to become proficient at assessing yield by visual and tactile examination. Such knowledge to date has been acquired in teaching institutions, in wool buying firms or in woollen mills.

Apart from students, few people could devote the time to formal training in yield assessment and there is no information in the literature, as far as the

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authors are aware, on the visual estimation of yield. In this paper, a system of yield estimation for Australian wool is presented, together with some experimental evidence of the validity of this system.

The Proposed System

The Australian greasy wools may be classified broadly into fleece wools and skirtings in both the merino and crossbred clips. The fleece wools are further classified commercially into a number of styles, such as, merino spinners and topmaking fleeces, and good, average and inferior crossbred styles, according to the variations in physical properties. The spinners style of wool may be described as the better merino combing wools of good staple formation, containing little dirt and no more than a small amount of vegetable matter. Combing wools which carry an appreciable amount of dirt and vegetable matter are usually classed into topmaking styles. The classification into spinners and topmaking styles is not discrete as there is overlapping of average spinners and best topmaking wools. (Anon. 1954).

The proposed sytem for assessing the clean scoured yield of skirted fleece wools was compiled from the authors' studies of, and experience with, a wide variety of Australian clips. This system is based on approximate relationships between commercial counts and yields of two selected styles of wool, and adjustments are made for others. The basic styles of wool used in this system are:

(a) Skirted merino fleece wool of spinners type with good colour, warp length (see Table II) and free of vegetable matter.

(b) Good crossbred combing wool free of vegetable matter.

The approximate relationships between commercial counts and clean scoured yields of the above styles of fleece wools are presented in Table I.

TABLE I.

Approximate relation of commercial counts and yields at 16% *regain for the two basic styles of wool used in this system.*

Commercial Count	Yield (%)
46's	74
50's	73
56's	72
58's	71
60's	70
64's	69
66's	68
70's	67
74's	66
80's	65

It can therefore be readily appreciated that a large proportion of the greasy wool clip does not fit the description of the wool types to which Table I applies due to differences in sheep, geographical location and season. Therefore the yield differs according to the variations in colour, length, staple bulk, tips and the amount of dirt, vegetable matter and moisture. Hence it is necessary to adjust the yields in Table I for the various characteristics of these greasy wools. The appropriate percentage to be added to or subtracted from the basic yields of Table I for each characteristic is listed in Table II.

It must be pointed out that the deductions in Table II for "Topmaking Fleeces" apply only to good to inferior grades of this style, and that no deduction for this character is necessary for best topmaking wools as these are considered as spinners wools in this system. The distinction of the good, average and inferior topmaking wools is based chiefly on the degree of dirt penetration into the staples and the amount of colour in the wool. When a deduction from Table II is made for good to inferior topmaking wool no additional deduction for colour is necessary.

TABLE II.

Table of yield adjustments.

Source of Adjustment	Adjustment (%)
Colour:	
(i) best	+2
(ii) good	0
(iii) average	—2
(iv) inferior	—4
Length:	
(i) spinners warp* or shafty topmaking	0
(ii) spinners warp and half-warp** or good to average length topmaking	—2
(iii) spinners half-warp† or medium length topmaking	—4
Topmaking fleece‡:	
(i) good	—10
(ii) average	—12
(iii) inferior (very dusty)	—15
Tip:	
(i) greasy black	—8
(ii) oily	—2
(iii) wasty	—1
Staple bulk:	
(i) excellent	+1
(ii) good to average	0
(iii) poor	—2
Moisture:	
(i) dry feel	+3
(ii) average	0
(iii) damp feel	—3
Vegetable matter:	
(i) light burr or seed	—2
(ii) medium burr or seed	—4
Unskirted fleece	—5
Rams' wool	—5

*Over 3½" for 60's, 64's, 66's merino spinners fleece..
Over 3" for 70's.
Over 2⅝" for 74's, 80's.
**A mixture of warp and half-warp† lengths.
†Shorter than warp length, but longer than 1½".
‡When a deduction is made for "topmaking fleece" no adjustment for colour is necessary.

The suggested method for using this system is first to assess the commercial count of the greasy wool concerned. From Table I, a basic yield figure, corresponding to the count is found. Appropriate adjustment for each character from Table II is then applied to give the estimated yield.

A convenient way of memorising Table I is that a wool of 60's count has a yield of 70 per cent. Each increase of one commercial count is accompanied by a decrease of one per cent. in yield, and each decrease of one count by an increase of one per cent.

Yields estimated by this system are clean scoured yields. However, "dry combed" and "oil combed" yields are often used in the wool trade. The relation between these yields and clean scoured yield is not constant. This is because combing yields depend a great deal on the machinery and system of manufacture, as well as the soundness of the wool. An approximate adjustment to convert clean scoured yield to "dry combed" yield for sound wool would be – 2 to – 3 per cent. There would be little difference between clean scoured yield and "oil combed" yield.

The estimation of yield of lines such as crutchings, locks and bellies is not included in this system. These yields are generally more difficult to estimate because they are much more variable than fleeces. Extensive experience therefore is required to be able to assess these yields with reasonable accuracy. However, as a matter of comparison, the approximate yields for good-average crutchings is 55 per cent., for locks 45 per cent. and for bellies 55 per cent. Allowances have to be made for colour, length, dirt and vegetable matter.

The authors do not claim complete originality of this system. It is felt that people in the wool trade and teaching institutions may be aware of some of this technique, and although not using it in

the mechanical fashion suggested here, may be using it intuitively.

An experiment was designed to test the validity of this system.

Experiment on Yield Estimation

Material and Method

Four observers with a knowledge of commercial count of greasy wool, but untrained in assessing yield, estimated the yields of 53 samples of greasy wool, using the above system. The observers were given copies of Tables I and II, and verbally instructed in their use for a period lasting only a few minutes.

The styles of wool samples ranged from best spinners fleece to inferior topmaking fleece in the case of the merino wools, and from good to inferior fleece in the crossbred combing lines. There were 25 samples of spinners fleece, 15 of topmaking fleece, and 13 of crossbred fleece. The commercial counts of the samples ranged from 80's to 46's.

The samples were arranged in random order on large tables and were examined by all observers in no fixed order. The observers recorded on individual sheets their yield assessments in the form of commercial counts and the adjustments for each character listed in Table II. There was no discussion among observers. The estimated yields were subsequently calculated.

The next day the same samples were relabelled, again laid on the tables in random order, and all the operators repeated their estimations without reference to their first records.

The samples were subsequently scoured in our laboratory in a four bowl scouring plant by the method described by Turner *et al.* (1953).

Results and Discussion

The yield assessments by the four observers were compared with the actual yields determined in the laboratory. The mean differences from the actual yields, together with the standard deviations of the differences, are presented in Table III.

TABLE III.

Mean differences between the actual and the assessed yields and the repeatabilities of yield estimations by four observers.

Observers	Time of Assessment	Mean Difference (%)	Standard Deviation of Difference (%)	Repeatability
A	1st	0	4.3	
	2nd	—1.8	4.2	0.75
B	1st	—2.3	4.2	
	2nd	—2.8	3.9	0.76
C	1st	—3.5	4.9	
	2nd	—4.2	4.7	0.68
D	1st	1.0	4.4	
	2nd	—0.5	4.4	0.63

The mean differences between the estimated and actual yields ranged from zero to – 4 per cent., the overall mean deviation being about 2 per cent. These differences are reasonably small, in view of the fact that the observers were completely inexperienced in assessing wool yield.

The standard deviations of differences of the four observers are all of the same order of magnitude, being about 4½ per cent. This indicates that for approximately one fleece out of twenty an observer may possibly be in error by as much as 10 per cent. in the yield estimation. Roberts (1954) reported a standard deviation of difference of 3.1 per cent. for yields appraised by experienced wool buyers. Unpublished data of one of the authors (R. E. Chapman) show standard deviations of difference of the order of 4 per cent. for yields assessed by four experienced members of the wool trade. The figure of 4½ per cent. found in the present test compares moderately well with the above.

The repeatabilities (intra-class correlations) of yield assessment by the observers are also presented in Table III.

Apparently there is a slight difference among observers in their ability to repeat their performances, but the overall repeatability values are reasonably high.

An analysis of variance using the differences between the actual yields and those estimated by the four observers is presented in Table IV. This analysis is based on a "mixed model" (Kempthorne 1952), in which the classifications of "styles" and "times" are considered fixed, and "observers" and "fleeces" are the random classifications. The number of fleeces within each style was made equal in this analysis, so that simpler and more precise tests of significance for the various effects could be made. This was done by deleting at random data for 12 of the samples in the spinners style and for 2 of those in the topmaking style.

TABLE IV.

Analysis of variance of the differences between the actual yields and yields estimated by four observers.

Source of Variation	Degrees of Freedom	Mean Square
Styles	2	23.394
Observers	3	262.487***
Styles x observers .	6	67.266***
Fleeces	36	71.368***
Fleeces x observers	108	7.949**
Times	1	118.154
Times x styles	2	6.990
Times x observers .	3	10.316
Times x fleeces . ..	36	7.496
Times x styles x observers	6	0.743
Times x fleeces x observers	108	5.043

**P < 0.01.
***P < 0.001.

There are very highly significant "among observers" effects. Evidently there are real differences among observers in their interpretation of this system, but these differences are small (see Table III).

Although the "between times" term is non-significant, the mean differences in Table III show that all of the observers were more conservative in their repeat yield estimations. The first order interactions involving "times" are non-significant. Their values of mean squares are sufficiently small that it may be concluded that any interactions between these effects are negligible.

There are very highly significant differences in the errors of yield estimation from fleece to fleece. These differences are probably due to the presence of some extremely high yielding wools in the various styles, which all observers failed to detect. Examination of the data showed that all the observers made conservative yield estimations for these samples. This suggests that the system is probably slightly conservative in the assessment of very high yielding wools.

Although no significant difference is found among styles, the "styles x observers" interaction is significant, as also is the "fleeces x observers" interaction. Inspection of the adjustments made by the observers for each character showed that observer B made heavy deductions for colour and observer D for length of samples in all styles. On the other hand, observer C made heavy deductions for dirt in the samples of topmaking style of fleeces. The variations in the amount of adjustment may, in part, be due to differences in the observers' subjective appraisals of the wool characters, but probably more largely due to their inexperience in yield estimation. With more practice it is expected that observers would improve and make heavy deductions for any character only when warranted.

Although the observers differ in their amounts of adjustments, Table III shows that the observers are able to repeat their performances reasonably well. This is also indicated by the relatively small

mean square values of interactions involving "times" in Table IV.

It is recommended that prior to the application of this system, an initial inspection of a number of fleeces be made to set standards for the various adjustments. This should result in more consistent yield assessments. Laboratory checks of the accuracy of these estimations should be made where possible.

From the above evidence it may be concluded that this system of yield estimation can be used by inexperienced observers with reasonable accuracy.

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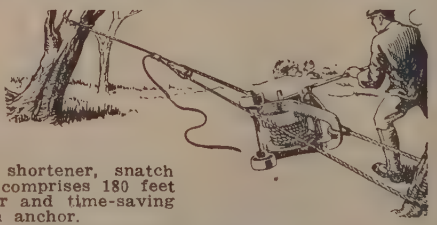

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THE GERMINATION OF *SPOROBOLUS VIRGINICUS*

By J. L. FRITH

Summary

The factors influencing the germination of *Sporobolus virginicus* have been the subject of a series of laboratory experiments. Light, KNO_3 and alternating temperature were found to exert a beneficial effect. The latter was essential for germination. It was found that maximum germination was obtained:

(a) in the light
(b) when a dilute solution of KNO_3 is supplied in the substrate
(c) when the temperature is alternated daily between 15 and 35°C. (approximately).

A constant temperature which would permit germination was not found. Because acid treatment and soaking in water were detrimental to germination it is considered that alternating temperature has nothing to do with the removal of physical barriers to germination. An hypothesis is put forward which explains the alternating temperature requirement as being due to the existence of two biochemical systems whose temperature limits are too far apart to allow germination to proceed at any constant temperature.

Introduction

In the Western Australian wheat belt between the 15 and 20 inch isohyets, saline seepages have developed on hillsides and along drainage lines as a result of the reduction of evapo-transpiration brought about by clearing. Besides being unproductive, such areas constitute an erosion hazard. The State Department of Agriculture has successfully used a salt tolerant grass, *Paspalum vaginatum*, on some seepages which remain moist throughout the summer. However, widespread use of this grass is hampered by its failure to set seed.

In 1949, the University Institute of Agriculture and the State Department cooperated in investigations of the use of *Sporobolus virginicus*, a salt tolerant grass native to southern Australia which does set viable seed. The results of this work have been published (Millington, Burvill and Marsh 1951).

In July 1952, eighteen different accessions of *S. virginicus* were sown in a field trial on a saline seepage at Grass Valley, W.A. No germination was observed until January 1953. A series of laboratory experiments to study some of the factors affecting the germination of *S. virginicus* was therefore undertaken.

The delay between sowing and germination of *S. virginicus* at Grass Valley suggested the presence of some type of dormancy in the seed. Crocker (1948) considers that dormancy may be caused by several mechanisms. Those which might have been operative in the case of *S. virginicus* were:

(1) the possession of a seed coat impermeable to water or oxygen, or too hard for the swelling embryo to rupture;

(2) an immaturity of the embryo necessitating after-ripening.

Toole (1941) made a study of the factors affecting the germination of seven species of *Sporobolus* (among which *S. virginicus* was not included). Four of these species germinated over a wide range of environmental conditions, but maximum germination was secured in presence of light, a 0.2 per cent. solution of KNO_3, and with alternating temperatures. Three species were relatively unaffected by these agents unless previously either chilled or treated for a few minutes with 71 per cent. H_2SO_4. According to Toole, the action of these agents was to soften the hard seed coat which existed under the gelatinous pericarp. The seed coat did not restrict the water absorption of any of the seven species examined.

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Toole suggested that it delays germination by offering resistance to the emergence of the radicle, or by restricting gas exchange.

Akamine (1944), working with *Sporobolus wrightii* and *S. airoides,* produced evidence to show that dormancy in these seeds was at least partly due to restriction of gas exchange by the seed coats. He obtained increased germination in response to cutting the coats, or soaking the seed in water for twenty-four hours or H_2SO_4 for one minute. He also obtained increased germination in response to daily temperature alternation between room temperature (about 24°C.) and 33°C. Though he admitted that the role of alternating temperature had not been determined, Akamine considered it was that of facilitating gas movement through the seed coat.

Neither Toole nor Akamine mention any interaction between the effects of light and KNO_3. Crocker and Barton (1952) in a general review of the subject of the effects of light on germinating seed, mention that KNO_3, thiourea, and other nitrogenous substances have been found to partially substitute for the light requirement of some light-favoured seeds.

Preliminary experiments conducted by the present writer showed that light, KNO_3 and alternating temperatures influenced germination beneficially, and that acid treatment and soaking in water were detrimental. Two further experiments, one on the effects of light and KNO_3 and the other on the effects of a series of alternating temperature regimes were subsequently performed and form the subject of this paper.

Experimental Work

(1) *Material*

Seed used in the experiments was of the following accessions:

N1974 (ex Freshwater Bay, W.A.). This strain corresponds closely to Gardner's (1952) description of the species. Compared with the other two strains used in the experiments, its growth is coarse. The culms are erect and from 10 to 30 cm. long. The leaves are dark bluish green. It flowers only in summer and the seed matures in the late summer and early autumn.

N401 (ex Capercup). This differs from Gardner's description of the species in having shorter culms and a more prostate and rhizomatous habit. The leaves are light green, 2½ to 5 cm. long, and somewhat narrower than in N1974. Flowering occurs during winter and seed matures during the early summer.

N394 (ex Capercup, W.A.). This is morphologically indistinguishable from N401.

Seed of N1974 was harvested from plants growing in their natural habitat at Freshwater Bay on the Swan River near Perth. Seed of the other two strains was harvested from the accumulation plots grown on the Crawley sand at the Institute of Agriculture. The seed was thoroughly cleaned by sieving and winnowing. It was sown with an automatic counter on 9 cm. diameter Whatman germination pads in Petri dishes.

(2) *The Effect of KNO_3 and Light on Germination*

This experiment was carried out to measure the effects of light and KNO_3 on germination and to determine the relation, if any, between the two.

Treatments:

Treatments were the eight combinations of the following variables:

(a) Moisture supplied as—
glass distilled water
0.1 per cent. KNO_3

(b) Light—no light
alternating light and dark

(c) Strain—N1974
N401

There were three replications.

Methods

(a) KNO_3: With the temperature alternation employed (20-35°C.), moisture loss from the dishes was considerable, and moisture had to be supplied twice daily. Under these conditions, the amount of moisture held by a germination pad had evaporated and was re-

placed after four or five days. Toole (1941) and others who have used KNO_3 to stimulate germination, have used a concentration of 0.2 per cent. In the present case, KNO_3 was supplied as a 0.1 per cent. solution and the germination pads were renewed every four or five days. The concentration of the solution in contact with the seed should therefore have varied between 0.1 per cent. and about 0.2 per cent. KNO_3. Germination pads were not renewed for seeds receiving distilled water.

(b) Light: Incandescent light was supplied in the 35°C. cabinet. Dishes receiving the control light treatment were placed in light-tight boxes. These dishes received about five minutes of room lighting each day when germination was counted and moisture replenished. Every fourth day they received about thirty minutes of dimmed room lighting when the pads were renewed. Care was taken to expose the "no light" dishes in each block for the same length of time.

(c) Subsequent Handling: Dishes were kept at 20°C. from 5 p.m. to 9 a.m. and at 35°C from 9 a.m. to 5 p.m.

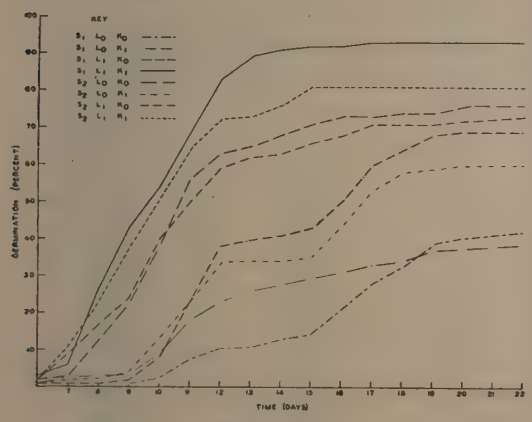

Figure 1.
Germination of two strains of Sporobolus virginicus with and without light and KNO_3 solution. The symbols represent the treatments as follows:
S_1 N1974.
S_2 N401.
L_0 "no light."
L_1 alternating light and dark.
K_0 distilled water.
K_1 KNO_3 solution.

Germination began on the fifth day after sowing and counts of germinated seed were made daily at 9 a.m. thereafter. The experiment was discontinued on the twenty-third day after sowing.

Results

There was one missing value in the results due to the breaking of a dish containing the N1974-light-KNO_3 treatment on the tenth day after sowing. Until this time germination in this treatment had been almost identical in each block, two blocks being exactly the same and the third differing by one germinated seed. The missing value was supplied by the iterative method of Snedecor (1946).

An examination of Figure 1 in which the germination percentage for each treatment is plotted against time, reveals that the relation between treatments changed during the course of the experiment. However, as twenty-three days is not an unduly long time for *S. virginicus* to germinate, only final totals have been taken for analysis. The results are shown in Table I.

The main effects are evident from the table. The negative interaction between light and KNO_3 is significant at the 5 per cent. level for N401 but not for N1974. The interaction between KNO_3 and strain is significant at the 5 per cent. level when the effect of light is eliminated; the response of N1974 to KNO_3 is greater than that of N401.

TABLE 1.

The effect of light and KNO_3 on the germination of two strains of Sporobolus virginicus.

(*Values are germination percentages and are the means of three replicates*)

	Light		Dark	
	KNO_3	Distilled Water	KNO_3	Distilled Water
N1974	93.25	75.38	69.50	41.25
N401	81.25	72.88	59.13	38.13

Difference required for significance:
5% : 6.66
1% : 9.27

(3) *The Effect of Various Alternating Temperature Regimes on Germination*

An alternating temperature of 20-35°C. had given good germination of *S. virginicus*, though various constant temperatures had given none. This experiment was conducted to explore the limits of temperature alternation which would be tolerated by germinating seed, and the possibility that the 20-35°C. alternation was not the ideal.

Treatments

Treatments were the following temperature alternations:

1. 25-35°C.; 2. 25-30°C.; 3. 20-35°C.;
4. 20-30°C.; 5. 20-25°C.; 6. 15-35°C.;
7. 15-30°C.; 8. 15-25°C.; 9. 10-35°C.;
10. 10-30°C.; 11. 10-25°C.; 12. 10-20°C.

Petri dishes containing the seed were held at the first (lower) temperature for sixteen hours and at the second (upper) temperature for the remaining eight. Two strains, N1974 and N394 were used but the data for these have been treated separately. There were three replications.

Methods

One hundred seeds were sown in each dish. The pads were watered with 0.1 per cent. KNO_3 solution and changed every three or four days.

Light was supplied during the period at the higher temperature. At all higher temperatures other than 35°C. fluorescent lighting was used. Incandescent lighting was used at 35°C. This was an undesirable but also unavoidable limitation of the equipment available. When germination commenced it was counted daily.

Results

There was no germination of either strain subjected to treatment 12 (10-20°C.). Under treatment 5 (20-25°C.), N1974 germinated only eleven per cent. by the twenty-seventh day and N394 not at all.

The remainder of the data have been analysed on the basis of the number of days taken by seed to achieve a certain germination percentage, and again on the basis of the percentage germination achieved on each of two selected days.

TABLE II.

Effect of alternating temperatures on germination.
(*Germination figures are the totals of the square roots of three values.*)

Treatment Number	Temperatures	Strain N1974		Strain N394	
		17th day	27th day	17th day	27th day
6	15-35°C.	27.4	28.0	24.6	25.0
9	10-35	26.9	27.6	24.5	24.9
3	20-35	26.6	27.7	21.8	24.7
7	15-30	26.6	27.7	23.6	24.8
4	20-30	25.4	27.6	17.1	21.0
10	10-30	25.1	26.1	22.8	24.4
8	15-25	15.9	26.2	8.4	17.0
2	25-30	13.6	18.2	7.0	8.1
1	25-35	13.4	25.2	10.8	12.4
11	10-25	5.9	16.4	7.3	15.8
Difference for Significance					
	5%	1.51		2.82	
	1%	2.07		3.87	
	0.1%	2.81		5.27	

TABLE III.

Effect of alternating temperatures on time taken to germinate.

Treatment Number	Temperatures	Time in days to achieve					
		25% germination		50% germination		75% germination	
		N1974	N394	N1974	N394	N1974	N394
6	15-35°C.	10.1	12.9	11.5	15.6	13.8	—
9	10-35	10.8	13.2	12.4	15.8	15.2	—
3	20-35	10.7	16.5	13.0	20.2	16.0	—
7	15-30	11.0	15.9	13.0	18.7	16.2	—
4	20-30	11.6	21.6	13.9	—	19.3	—
10	10-30	12.1	16.4	14.5	20.0	18.4	—
8	15-25	16.5	—	19.5	—	—	—
11	10-25	19.9	—	20.9	—	—	—
Difference for Significance							
	5%	2.64	2.64	2.01	3.36	3.15	
	1%	3.75	3.75	2.78	4.88	4.45	

For the purpose of the latter analysis, square roots of germination percentage have been used. The results are summarised in Tables II and III. Germination is plotted against time in Figures 2 and 3.

The temperature of the cabinets fluctuated through 5°C. in twenty-four hours. Temperature measurements were made with mercury-in-glass thermometers. The temperature values assigned to the treatments are therefore only nominal and comparisons cannot safely be carried outside the conditions of this particular experiment.

The temperature alternation giving most rapid and complete germination was 15-35°C. Though it consistently ranked highest it was significantly superior to 20-35°C. only in the case of N394.

At any one lower temperature, 35°C. ranks superior to 30°C. as an upper tem-

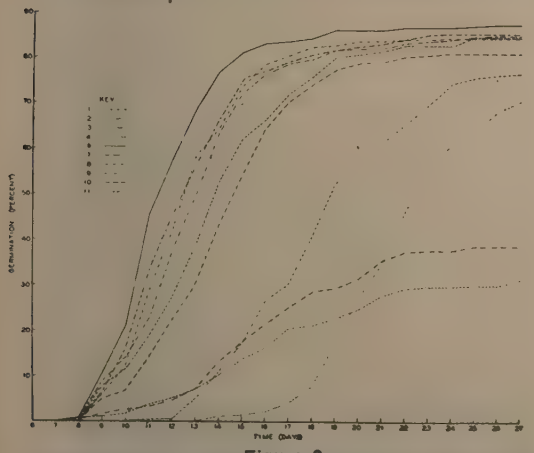

Figure 2.
Germination of Sporobolus virginicus N1974 under ten different alternations of temperature. The treatments and their corresponding numbers are listed in the text.

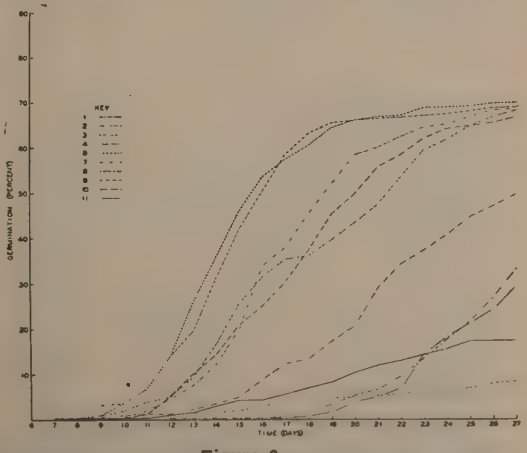

Figure 3.
Germination of Sporobolus virginicus N394 under ten different alternations of temperature. The treatments and their corresponding numbers are listed in the text.

perature of the alternation, except for one case where in N1974, 25-30°C. is significantly superior to 25-35°C. In several instances the difference between the upper temperatures of 30°C. and 35°C. is significant.

Discussion

(1) *Light and KNO_3*

The response of germination to light and KNO_3 solution partly explains the delay in the germination of seed sown at Grass Valley. Unfortunately, any depth which allows seed to receive sufficient light is likely to contain a lethal concentration of salt. Two possible solutions to this problem may be (i) the application of nitrate and (ii) the sowing of seed in narrow furrows. The latter practice should bring about a diminution in the salt concentration in the vicinity of the seed as the moisture rises by capillarity to the adjacent ridges and evaporates leaving the salt there. This principle has been used successfully elsewhere (Wadleigh and Fireman 1948). Both propositions warrant field investigation.

The results of this experiment confirm for *Sporobolus virginicus* what Toole and Akamine found for other species of *Sporobolus*. The statement of Crocker and Barton (1952) that KNO_3 can to some extent replace light as a factor promoting germination of some light-flavoured seeds is also supported.

(2) *Alternating Temperature*

The question arises as to why alternating temperature should be required for the germination of this species. Possible functions of alternating temperature might be (i) the removal of some physical impediment to germination, or (ii) the provision of conditions which allow the operation of inter-dependent processes whose optimum temperatures differ widely and whose respective maximum and minimum do not overlap.

Akamine (1944) suggests that alternating temperature breaks down or renders permeable "encasing structures interfering with oxygen absorption by the embryo . . .", but he makes this suggestion merely because alternating temperatures had the same effect (i.e., that of increasing germination) as acid treatment or scarification of the seed coat. In the present experiments, acid treatment was definitely detrimental, yet alternating temperature was essential for germination.

The response to alternating temperature can also be explained as being due to the existence of widely different temperature optima for the various processes concerned in germination. In any growth and development, many different biochemical processes must take place more or less concurrently. It is unlikely that the optima for all these coincide, although it happens nearly always that they are close enough for growth to proceed at the one temperature. In the case of *Sporobolus virginicus*, it could be that two processes (or two sets of processes) essential to germination occur, one of which has an optimum temperature below 15°C. and the other of which has an optimum at or above 35°C.

At temperatures above 25°C., the low temperature process (and therefore germination) is seriously impeded. This may involve inactivation or destruction of the agents concerned; for seed subjected to treatments 1 and 2 (25-35°C. and 25-30°C., respectively) though among the first to germinate, subsequently gave the slowest rates and lowest totals of germination. At temperatures below 20°C. the hypothetical high temperature process was brought almost to a standstill; no germination was recorded in treatment 12 (10-20°C.). Seed subjected to treatments 11 and 8 (10-25°C. and 15-25°C.) was slow to commence germination but once started, maintained a fairly fast rate until the completion of the experiment. Here the high temperature process would be slowed but not destroyed by the prevailing low temperatures. The low germination recorded in treatment 5 (20-25°C.) could be due to

temperature within this range being so far removed from the optimum of either process that both are limiting.

Although the second construction placed upon the data seems to fit them well, it is not proven by them. They suffer from inadequacies of the range of treatments applied and of the equipment employed. In any case, it is doubtful whether this approach can do much more than provide the facts which suggest but do not prove the hypothesis offered here. If alternating temperature is merely required to render a membrane permeable to gas, then removal of the embryo or cutting the seed coat should obviate this need and the treated seed should germinate at some constant temperature. Should it still require alternating temperature, then the data from this experiment provide some circumstantial evidence for the existence of some mechanism such as that outlined above.

Acknowledgments

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BOOK REVIEWS

THE PRINCIPLES OF FUNGICIDAL ACTION

By Dr. J. G. HORSFALL

(*The Chronica Botanica Co., Waltham, Mass., U.S.A.; N. H. Seward Pty. Ltd., Melbourne, C.*1. $6.50)

This is not, as the author points out, a "cook book." That is to say, it is not primarily a spray manual or an orchardists handbook, and it does not attempt to advise on the control of specific diseases or give lists of recommended fungicides. Nevertheless, it contains a great deal of interest to the applied man who is at all interested, as he should be, in the theoretical background of his subject. Primarily, as the title indicates, this is a review of the whole field of fungicides, in relation to their mode of action.

Dr. Horsfall starts by considering what fungicidal action is and the various methods which have been adopted to measure it. He deals with the methods by which a fungicide may reach its site of action, and the ways in which it may then affect the fungus. The next chapter covers the important and controversial aspect of chelation, which he points out must be considered as an important mechanism of fungitoxicity. Further chapters consider the actions of metals, of sulphur, organic sulphur compounds, quinones, and heterocyclic compounds. The book fittingly concludes with a discussion of the new and growing trend to chemotherapy, or the chemical control of plant diseases after the pathogen has entered the plant. Each subject is dealt with according to the same plan, a review of the literature for and against each theory of action, followed by a summary and presentation of the author's current views.

The field covered in some 230 pages is vast, and hence the space given to each subject is necessarily limited, perhaps too limited for the specialist in any particular aspect. However, the book is obviously intended to give a clear and easily read picture of general developments and trends over the whole subject, and Dr. Horsfall, who is, of course, one of the leading workers in this science, succeeds as few others could. This book is naturally a 'must' for anyone interested in fungicide developments.

F. J. D. THOMAS.

SALT STATUS AND TIME OF BURSTING OF THE SULTANA

Thomas (1934) has listed premature bud burst as one effect of excessive soil salinity on the vine. During the course of investigations in which the time of bursting of sultana vines was determined (Antcliff, Webster, and May 1957) salt determinations were also made to see whether there was any relation between salt and time of bursting in the absence of apparent salt damage. 54 vines were examined on each of three sites in the Sunraysia district for four seasons. Samples of 25 petioles were taken from each vine in the first week in January and chloride determined in accordance with methods described by Woodham (1956).

Correlation coefficients relating mean time of bursting per vine in spring each season on each site to the chloride determinations made in the preceding and following summers are shown in Table I.

TABLE I.

Correlation coefficients relating mean time of bursting per vine and chloride content in the preceding and following summer.

Season		Red Cliffs 149	Red Cliffs 695	Mildura
1951-52	same year	-0.217	-0.476***	-0.465***
1952-53	same year	-0.373**	-0.310*	-0.339*
	previous year	-0.245	-0.355*	-0.477***
1953-54	same year	-0.196	-0.318*	-0.210
	previous year	-0.251	-0.421**	-0.314*
1954-55	same year	-0.290*	-0.173	-0.038
	previous year	-0.223	-0.251	-0.160

*Significant at the 5 per cent. level.
**Significant at the 1 per cent. level.
***Significant at the 0.1 per cent. level.

The correlation was invariably negative —i.e., the higher the chloride the earlier the burst—but it was not always significant. Higher correlations were generally obtained when the chloride figures for the preceding summer were used. The vines tended to be consistent in both chloride and time of bursting over the period of the experiment. The mean chloride value for each site in each season is shown in Table II. The steady rise in chloride on the Mildura site, which was

TABLE II.

Mean chloride content per vine on three sites in four seasons.

Season	Red Cliffs 149	Red Cliffs 695	Mildura
1952	0.99	0.99	1.27
1953	1.14	1.06	1.49
1954	1.05	0.78	1.57
1955	1.54	1.27	1.95

undrained, will be noted, but even in 1954-55 no symptoms of serious salt damage were observed on the vines. Correlation coefficients relating chloride to weight of fresh fruit produced per vine are shown in Table III. Significant negative correlations, which might indicate

TABLE III.

Correlation coefficients relating chloride content to weight of fresh fruit produced per vine.

Season	Red Cliffs 149	Red Cliffs 695	Mildura
1951-52 ..	0.457***	—0.415**	0.281*
1952-53 ..	0.240	—0.349*	0.074
1953-54 ..	0.376**	—0.384**	—0.133
1954-55 ..	0.220	0.068	0.344*

*Significant at the 5 per cent. level.
**Significant at the 1 per cent. level.
***Significant at the 0.1 per cent. level.

that salt was reaching excessive levels, were found on only one site. The significant positive correlations found on the other sites should not be taken to indicate that salt is beneficial at low levels. Presumably the factors increasing yield also favoured salt accumulation.

Salt status was related to time of bursting in the absence of obvious salt damage, and the relation was such that premature bud burst might be expected to follow excessive soil salinity. However the relation was not very close, and was no more pronounced on the site where salt appeared to depress yield than on the other sites. It would appear that while excessive salt will cause early bud burst, it is not the major factor affecting time of bursting. Early bud burst should not, by itself, be taken as a sign of excess salt.

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ARTIFICIAL INFESTATION OF ORANGES WITH THE QUEENSLAND FRUIT FLY

During the course of investigations with the Queensland Fruit Fly, *Strumeta* (*Dacus*) *tryoni,* into procedures for disinfesting citrus fruits, which would be acceptable to plant quarantine authorities in importing countries, it soon became apparent that adequate supplies of naturally infested main crop oranges could not be obtained.

To overcome this difficulty an effective method of artificially infesting oranges has been developed involving hypodermic injection of fruit-fly eggs into the fruit.

When dealing with insect eggs, it is necessary to place them in proximity to the food which will be required by the newly hatched larvae. It has been practice here when testing systemic insecticides against Queensland Fruit Fly to insert eggs into the flesh of stone or pome fruits in a small incision which is then sealed back in place with adhesive tape. Larval hatchings of the order of 80% or 90% of eggs have been regularly obtained by this method.

To test the efficiency of this method on citrus fruits, exploratory investigations were commenced in the winter of 1955 and Wheeney grapefruit, Washington Navel oranges, Late Valencia oranges and Eureka lemons were tested. Eggs were placed in various parts of the fruit using a cataract scalpel.

From this preliminary work it was concluded that:—

(a) Contact with the oil of each variety of citrus fruit tested, killed the eggs and young larvae of the fly.

(b) In the winter months the albedo of maincrop Late Valencia oranges and of Eureka lemon skin provides an unsuitable medium for survival of newly hatched maggots, whereas normal development could proceed in the albedo of Wheeney grapefruit, old second crop Late Valencia oranges and Washington Navel oranges. The albedo or pith represents the usual site for deposition of the eggs by the female fly.

(c) The placing of eggs in close proximity to the juice or juice cells of each variety of citrus tested, led to a normal development of maggots in the fruit. The rate of maggot development was most rapid in those varieties in which the albedo was in a suitable condition for larval development.

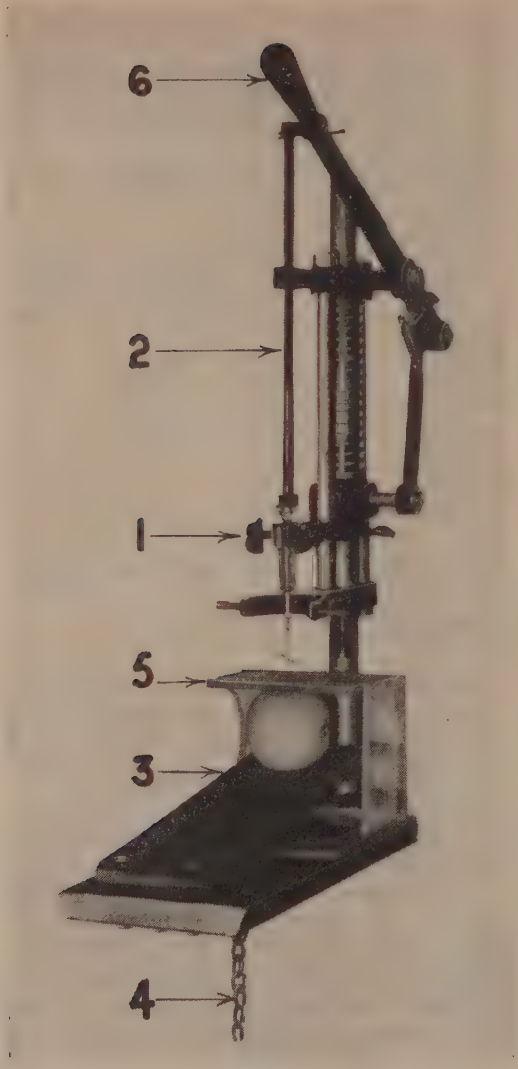

Figure 1.
Fruit Injection Stand. (Details given in text.)

It thus became clear that controlled placement of eggs would be necessary in work requiring experimental cultures of maggots in Late Valencia oranges. Further, as the number of eggs per fruit would also need to be controlled, the principle of hypodermic injection was investigated. This required the use of a suitable hypodermic needle, a suitable liquid egg-dispersing medium, and a syringe which would not damage the eggs.

These requirements were met and the syringe method was found to be practicable although its use as a hand-held instrument was slow and a large variation in egg dosage was unavoidable.

To overcome these disadvantages a fruit-injection stand was made to hold both fruit and syringe which enabled control of both dosage of egg suspension and, within the limits of the needle used, the depth of placement of egg suspension within the fruit. The equipment was made by attaching modifications to a handyman-type of drill stand as shown in Figure 1.

The following infestation procedure was found effective:—

The Eggs

These are obtained by training flies to deposit their eggs through needle-holes in the side of an inverted wax paper or plastic cup. The rim of the cup is sealed to a glass plate with wax after enclosing a piece of fruit on the glass to provide the necessary fruit "scent". The whole is then exposed in a cage containing gravid flies so that up to several thousand eggs may be obtained in a few hours.

The eggs (Figure 2) are kept in a moist atmosphere by covering the cup with wet cotton wool and may be stored at 40°F. for several days. It was found best to leave the eggs undisturbed as long as possible before handling and a period of two days was generally employed. Hatching eggs and newly-hatched maggots can be handled similarly.

Fruit fly eggs are naturally provided with a "sticky" coating which tends to set after a short time and adhere them in position on the inner surface of the cup. In order to obtain the eggs in a usable condition they are washed in water and allowed to settle to the bottom of the container, after which the excess water is poured off and further free water removed with blotting paper.

The Egg Suspension

The medium used is a broken gel of agar, of sufficient consistency to disperse eggs but liquid enough for use with an hypodermic needle of gauge 20. It can be prepared some months in advance,

tubed into standard zinc coated tooth-paste-type tubes and stored in a refrigerator or cool place.

The medium is prepared by adding 0.4 per cent. of powdered agar to cool distilled water and dissolving by gentle boiling. While still hot a preservative such as methyl-p-hydroxy benzoate at 0.1 per cent. and orange juice at 1.0 per cent. are added separately.

On cooling, the liquid commences to gel and may be satisfactorily broken by vigorous stirring. A uniform and satisfactory gel is obtained by pressing the 0.4 per cent. agar mixture, after setting, through fine muslin.

A usable egg-suspension is obtained by adding eggs to the medium at the rate of up to 500 per ml, and mixing thoroughly. Cultures of micro-organisms such as yeast and *Lactobacilli*, found to help in maggot establishment, may be added to the medium at this stage. It is important to avoid the production of air bubbles in the agar-suspensions as this can adversely affect subsequent operation of the injection procedure.

The Syringe

A suitable syringe was found in an all-glass type, of 3 ml capacity, with Luer-lock needle attachment, but a well shaped flat collar is needed since this part is used for holding the syringe in a modified laboratory flask clamp.

The Needles

For filling the syringe with egg-suspension an 18 gauge needle is satisfactory. For injection, 20 gauge needles are used. A needle $1\frac{5}{8}$ inches in length is suitable for citrus fruits, but the point of the needle should be modified for side delivery. Just back from the proximal edge of the tip bevel a new orifice is filed out and the tip orifice is stopped up. A needle so modified will rarely become clogged by the fibrous strands in citrus fruits.

This needle injection method has been adapted to apples by soldering a small metal flange to the non-bevel side of the needle tip. After insertion of the needle

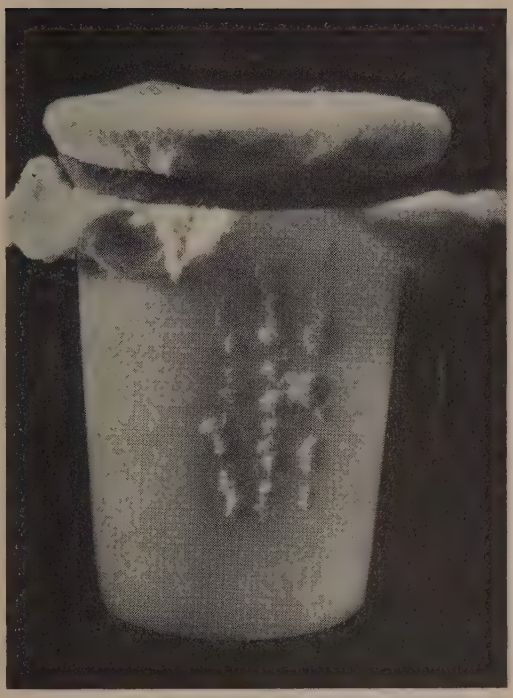

Figure 2.
Eggs of Queensland Fruit Fly in plastic cup.

the apple is revolved so that the flange gouged out a small cavity in the flesh for the retention of the injection. Satisfactory infestations may be obtained in apples by depositing eggs within the core cavities but with Granny Smith apples it was found that the young larvae did not always escape successfully after placing eggs in this position.

The Fruit Injection Stand

After filling with egg-suspension, the syringe is clamped vertically in a laboratory Flask Clamp (see Figure 1 (1)) modified to prevent vertical movement when the needle is plunged into the fruit. The Plunger Drive Screw (2) is previously elevated to clear the top of the loaded syringe plunger. After the syringe has been clamped the Plunger Drive Screw (2) can be lowered gently until egg suspension shows at the needle orifice. The spring-tensioned Fruit-holding Plate (3) is then lowered by means of a foot pedal at the base of Pedal Chain

(4). An orange is placed in position and held firmly by the returning spring-tensioned Fruit-holding Plate (3) against the Positioning Hole in the perspex Fruit-Deck (5).

The Plunging Lever (6) is then lowered until stopped by the basal attachment of the Syringe Clamp (1), the height setting of which can thus be used to control depth of injection into the fruit. The Lever (6) is held in this position until the Plunger Drive Screw (2) is given a regulated downward twist and a controlled dose of eggs so injected.

Depending on the texture of oranges handled, some vertical oscillation of the needle may be found desirable, before final retraction from a fruit, which can then be released ready for the next. The motions involved can be synchronised by one operator with a little practice so that the time taken up by the actual injection process is only a few seconds per fruit.

Preparation and Post-Injection Treatment of Oranges

Under humid conditions citrus fruits in storage are subject to mould wastage. Measures have to be taken in this work to prevent loss due to mould development. The following practices have been employed to this end:—

(a) Dipping the experimental fruit for two minutes in a 2.0 per cent. aqueous solution of sodium ortho phenyl phenate and allowing the residue to dry on. This is a more drastic treatment than that employed in packing shed practice but is desirable when mould infection is severe. Treatment a few days ahead of injection will allow for the discarding of any previously infected fruit before use.

(b) Simple surface sterilizing of fruit by dipping in 95 per cent. alcohol. This is considered adequate only when relatively mould-free fruit is handled. Alcohol is also used for sterilizing equipment from time to time but needles and other egg-handling equipment are always sterilized in boiling water.

(c) Plugging the rind at the site of the injection wound is necessary. The needle shank itself leaves an inconspicuous hole in citrus rind. This hole is enlarged in the rind and plugged with wax. A small metal collar can be soldered round the proximal end of the needle shank so that the hole is enlarged automatically as the needle is plunged into the fruit. A suitable plastic plugging mixture is made from resin, beeswax, pure mutton fat and paraffin wax, and is applied in the molten state after the surface of the injection wound has dried.

(d) Wrapping of experimental fruit in diphenyl impregnated wraps provides further protection against mould during the holding period necessary for maggot development.

(e) Storage at 85°F. in a relatively dry atmosphere has been used for both mould retardation and rapid maggot development; under these conditions early maturing larvae may frequently be found leaving the artificially infested oranges on the seventh day after injection of the eggs.

Acknowledgment

This work was carried out as part of the co-operative investigations into the post-harvest treatment of fruit against fruit fly, being carried out by the N.S.W. Department of Agriculture and the Commonwealth Scientific and Industrial Research Organization. The help and encouragement received at all times from the various investigators is gratefully acknowledged.

Figure 1 was photographed by P. R. Maguire, C.S.I.R.O. Division of Food Preservation and Transport, and Figure 2, of fruit fly eggs as received by courtesy of G. J. Snowball, C.S.I.R.O. Biological Control Sub-Station, was photographed by P. Swan, N.S.W. Department of Agriculture.

A. H. FRIEND.
Department of Agriculture,
Sydney, N.S.W.

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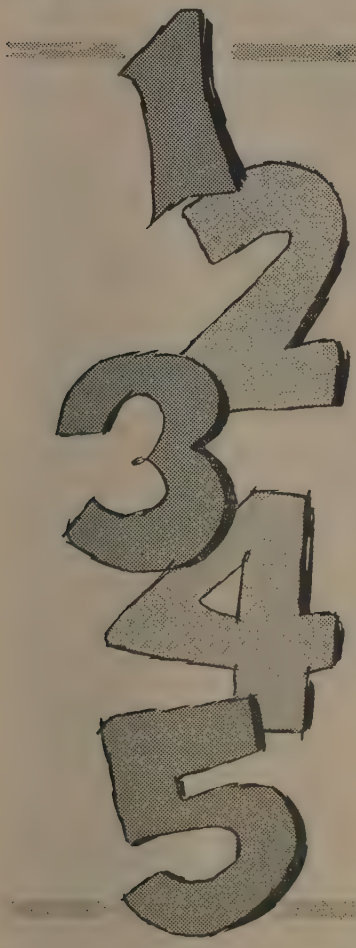

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TALKS

The Electronic Calculator SILIAC—a convenient tool in Biology.

Dr. A. S. Fraser, Animal Genetics Section, CSIRO in a Staff Talk.

Without going into the electronic details of the machine, Dr. Fraser explained the types of processes used to perform calculations. In the simplest of terms SILIAC does virtually the same operation as performed by an ordinary desk calculator, adding in and out of a number of registers and counters. It does this at speeds and with an accuracy which would themselves rank it far ahead of any desk calculator. Equally important it has a very valuable ability to examine results and to vary its programme of operations according to a prearranged plan based on the nature of results.

Any computation is broken up into its basic arithmetical operations for programming purposes as the machine must be told what to do at all stages. A library of instructions to the machine for typical calculations and sub-calculations has been built up to avoid all this detailed work wherever a new calculation is required. This library is extremely good in the field of higher mathematical work and is rapidly being built up on the statistical side.

Both the programme and the data to be processed is fed into the machine on a tape on which coded holes have been punched by a teletype machine. The library programmes detail the appropriate punching for the teletype operator.

Dr. Fraser explained that although he had been having data processed by SILIAC for some time it was only in the previous six weeks that he had been doing his own programming. Even though he had been forced to do quite a lot of detailed programming, as library routines were not available in a form suitable for his purpose, he felt fully capable of coping with any of his work. It should not be difficult for any research worker to handle his own programming.

Referring to the value of the machine in terms of timesaving and calculations that it makes possible Dr. Fraser pointed out that once the data has been punched on the tape it can be run through the machine any number of times for subsequent processing. The answers are typed out by the machine, the actual setting out being arranged in the initial programming, so that the use of the machine becomes feasible in virtually any instance where data would have to be typed if the machine were not used. The time taken with the teletype machine is equivalent to that a typist would require. Drawing on his own experience he pointed out that not only does the machine permit very much faster calculations but also encourages one to take analysis further. Work that would be impossible on desk calculators becomes quite feasible on SILIAC.

The Nature of the Major Limitations to the Increase of Animal Production.

Mr. W. M. Willoughby, Division of Plant Industry, CSIRO, Canberra, in a Staff talk.

Mr. Willoughby stated that he did not wish to talk about his own work, but was taking the opportunity to broadly state, particularly for those not very familiar with the Australian pastoral scene, the nature of the major limitations to increase animal production. Animal products contributed the greater portion of the national and export wealth. Pasture is virtually the only raw material used, so deficiencies in its quality or quantity have huge economic repercussions. Typical pasture availability curves for various Australian regions over twelve-month periods were presented to illustrate the long seasonal periods when animals were underfed, and consequently not producing at their best, and the generally short seasonal period where animals were adequately fed for maximum production. Underfeeding could occur not only under conditions of gross insufficiency of plant material, but very often in the presence of adequate material, which was either refused or was of low digestibility. These latter conditions persisted for quite some time each year, sheep and cattle being presented with substantial amounts of "dry feed" on which they lost weight—using up mutton and beef to stay alive.

It was quite obvious—indeed it was fatuous to have to state it—that increasing plant production in the periods when the animals were already presented with many times more than they could already consume—would be quite a useless endeavour. It was possible that such could even shorten the period of feed adequacy and consequently reduce animal production. It would certainly lead to much greater wastage of material (excess production over consumption) than at present.

Greater animal production depended chiefly on:

(i) increasing the length of the plant growing season (or increasing the rate of pasture production in those periods where it is now low, even at the expense of decreasing more than proportionately in those periods where it is now high); or

(ii) maintaining the palatability *and* digestibility of plant material when it matures.

In answer to a question, it was stated that conservation of excess material was being examined, but mainly as a technique (among others) to alter the pasture availability curve in order to study plant-animal relationship. To suggest that plants should be used to fully exploit the short optimum growing conditions, and then should be conserved and fed back to the animals was a negative approach. Firstly it replaced the harvesting functions of the

animal with much more expensive mechanical devices. Secondly it allowed of enormous wastage in preparation for and during storage. Thirdly it would require over half of the grazed portion of the continent to be traversed with harvesting machinery in a few weeks each year. Though conservation may have a definite place under present circumstances the aim of this Division should be to try to reduce—not increase —its necessity.

The Soils and Agriculture of Brunei.

Recently, Mr. R. M. Baker, of the S.A. Department of Agriculture, and Mr. G. Blackburn, of CSIRO's Division of Soils, undertook a Soil Survey in Brunei, North Borneo. They reported on the trip at a meeting of the S.A. Branch.

Mr. Baker: Mr. Baker explained that Brunei Island covers an area of 300,000 square miles at a latitude of 0-2°. Brunei State which is a small part of the Island covers 50,000 square miles. Population is 60,000 consisting of half Malay, quarter Chinese with the additional quarter made up of local races. The Malay population are mainly administrators, with the Chinese looking after the State's commerce.

Climate is tropical, temperature varying little beyond 75-90°F. Rainfall 100".

The State is both a Sultanate and a British Protectorate and run primarily by British Colonial Service of Europeans.

Economy of the State is based on oil, producing 100,000 barrels daily with an annual value of $265 x 10^6$. Of lesser importance is the rubber industry $1m.

The population live in mixed villages or kampongs with the houses built on piles driven into the river silt.

Rubber and wet paddy excepted, there is no permanent agriculture. Primary jungle is cleaned, used for hill paddy for 3-6 years and then abandoned due to loss of nutrients. No fertilisers are used and under jungle clearing conditions none are needed. Slopes are often in 40-50% range, soils sandy with yellow clay subsoil with no marked horizons.

Some forestry is practised but difficult to log due to swamp and rainfall.

Department of Agriculture has three field stations, 1 animal breeding station and 1 rubber nursery, these are demonstration stations of poor quality. Budded citrus and rubber trees are distributed to native farmers from these nurseries. A breeding programme for imported A.I.S. has been a failure; cows produce 1 pint of milk daily.

Four rubber estates cover 30,000 acres. These are tapped after 4-5 years and have an expected life of 30 years. No fertilisers are used. Undergrowth is slashed periodically. Some trees have difficulty in remaining upright in the sodden conditions. Management is mostly poor. If the price of rubber is good then the trees are heavily drained.

Mr. Blackburn: Mr. Blackburn outlined the nature of their task of carrying out a soil survey. It was expected that Messrs. Blackburn and Baker would produce a detailed soil map of the 50 square miles of country to be surveyed, with land use mapped out. Consultants could then be employed to direct use of these soils. This was not possible as there was no base map of area to start with and it was only by reference to photos, etc. that positions on survey line could be determined. Soil survey was carried out by examination of profiles along parallel tracks 20-40 chains apart cut through forests.

Visibility was poor in their main forest, being worse in regrowth than in primary forest.

Other difficulties to be accustomed to were climate, language of the people, etc.

Soils and Topography: The country is hilly with swamps on the low-lying areas. Run-off very high and drainage of low areas often restricted by tidal influences. Large areas of peat.

The soils are so poor that detailed soil map of little use.

On Hills: Yellow soils with no important profile feature, consists of a few inches of organic layer with a gradual increase in texture with depth. Sometimes mottling, indicating impeded drainage but generally these soils are well drained becoming acid in a short time.

Soils apparently developed from alternating marine sandstones and poorly consolidated clays.

Rocks, etc., mostly infertile and highly weathered with few fossils.

No evidence of laterite and the soils are not podsols although acid. There are no bleach layers.

Low Level Podsols: Are found near beaches, similar to soils of South East.

Peat: Large areas of peat have been formed due to poor drainage, high rainfall, changes in sea level (10-12 feet common) often to considerable depths.

The most valuable soil was a dark alluvial swamp clay of high fertility. This soil consists of well structured black top soil and a putty coloured structureless clay at water level. Ideally suited for wet paddy.

Land Use and Nutritional Status: The agricultural class of the native people class the soils according to suitability for rice growing, the black soils the least favoured. The sandy soils may be useful for pineapples.

Peat known as "rotten soil" and not used unless absolutely necessary—acid and deficient.

P and K low levels similar to Coonalpyn Downs.

Ca greatest deficiency—all soils acid rocks lacking.

Burning of vegetation as in initial clearing supplied some K and Ca.

No fertilisers used for rice, rubber or pineapples, although all respond. Some Buffalo dung and bat guano (from caves) used where available for small gardens.

Rubber Trees may not yield more with pl and P but grow better early in life.

Pineapples: Bushes last up to 10 years—contrary to commercial practice in Queensland,

result is poor quality. Poorest soils used and no attempt to get good varieties.

Rice: Irrigation of small areas—natural rainfall relied upon on hills, sometimes with poor establishment of crop when rain unreliable. Rice and imported crops—sago native crop, relied upon many years ago.

Food requirement estimated as ¾ ton paddy per family. 1 ton per acre a good crop in an irrigated area but often as low as a few hundred pounds per acre.

Conclusion: Much to be learnt from native people who know the country and vegetation very well. Questioning of local people a very valuable starting point.

There is great need to bring mapping up to date, photographs a necessity. Realised in Borneo that soil analysis valuable but not whole answer. Main need for trained resident scientific agriculturists.

Trace Elements in Animal Nutrition.

Dr. J. M. Harvey, Biochemist, Animal Research Institute, Brisbane.

The animal body contains a large number of mineral elements which occur both in combination with each other and in combination with organic constituents. While the physiological importance of some elements was recognised early, specific knowledge of their nutritional significance has been due to research during the last two to three decades. Many are under intensive study at the moment and much still remains to be done.

The discussion by Dr. Harvey was restricted to inorganic elements which occur in small amounts or traces. Those which are known to be essential are *iron, iodine, zinc, manganese, cobalt* and *copper*. Those which are not established as essential and which are definitely harmful in excess are *selenium, tellurium, molybdenum* and *fluorine*. The emphasis was placed on Australian and particularly Queensland experience with these elements.

Some Physical Properties of Soil from the Row and Inter-row Spaces of a Row Grass Pasture.

Mr. J. K. Leslie, Student Finalist, Queensland Branch Prize.

Soil beneath the grass row and the cultivated inter-row space, was examined within a row green panic (*Panicum maximum* var. *trichoglume*) pasture at Biloela Regional Experiment Station. This was done to compare the effects of grass and cultivation on soil structure under closely comparable conditions of environment and soil composition.

Surface soil of the row was well structured while that of the inter-row was hard and angular in structure, and almost devoid of grass roots. Below a depth of four inches, which is the maximum depth of cultivation, there were no observable differences in soil structure.

The infiltration rate of the row was 3.3 in./2 hr. almost seven times that of 0.5 in./2 hr. recorded for the inter-row space. The downward movement of water was very restricted beneath the inter-row, practically ceasing at a depth of two inches, while water moved freely down the profile beneath the grass row. This behaviour is considered largely due to the influence of roots and root channels under the row.

With the removal of roots and root channels and the destruction of structural peds in laboratory treatment of the soil, the row soil still retained a higher permeability than the inter-row soil. The permeability of 0-4 in. soil of the row was 1.29 in./2 hr. compared with 0.77 in./2 hr. for 0-4 in. soil of the inter-row. Below 4 in. the permeability was similar for both areas, averaging 1.02 in./2 hr. Thus structural differences do not occur below the depth of cultivation.

Permeability differences of the surface soil were not due to variation in water stable aggregate composition. Row and inter-row soils exhibited similar aggregate status for aggregates either 0.25 mm. or 0.05 mm. in diameter.

The surface soil thus possesses some undefined property, probably organic in nature which confers a higher permeability on the row soil than is possessed by the cultivated soil. It is considered that it is the absence of grass roots in the inter-row rather than a direct physical destruction of soil due to cultivation which is responsible for the bad structure of the inter-row soil.

It should be realized that although row pastures are more productive than sward pastures under our climatic conditions, they should not be regarded as a soil restoring ley, but as a grass crop.

The Response of Young Cotton Plants to Short Periods of Wilting.

Mr. G. Diatloff, Student Finalist, Queensland Branch Prize.

The growth response of young cotton plants subjected to wilting treatments of short duration was determined. The experiment was carried out in a glasshouse and the wilting treatments were of one, two and four weeks duration respectively.

Wilting treatments reduced growth during the period of wilting, but growth rates upon rewatering were greater than for the control plants. There was no indication that this recovery effect was complete at the final harvest. There were no significant depressions in growth rates in response to the wilting treatments.

It would appear that the changes that occurred in response to the water shortage were initiated relatively early in the drying cycle.

Variation in Weight of Grazing Cattle with Time of Day.

Miss D. E. Nunn, Student Finalist, Queensland Branch Prize.

An experiment was designed to give evidence of the most suitable times for weighing grazing cattle to give the least day to day variation as determined by statistical analysis.

Forty-five cattle were divided into five groups, each containing nine beasts each group being weighed at a set time over a period of seven days. The times chosen for weighing were 1 hr., 3 hr., 5 hr., and 7 hr., after sunrise and half an hour before sunset. No overnight fasting treatment was included due to the difficulties arising in the use of such treatment under practical conditions.

The cattle were grazed together on pastures offering maintenance ration only and were allowed free access to water at all times.

Results showed that weighings taken at 1 hr. after sunrise or half an hour before sunset, when the cattle graze as a herd, are likely to give the least daily variation.

Further trials under different environmental conditions are needed to substantiate these results and to determine the behaviour of animals under different environmental conditions. More attention should be given to correlations between grazing habits and weight variations.

Transportation and Storage of Fruit and Vegetables.

Dr. H. K. Pratt, of the University of California.

In commencing his address on current aspects of research on post-harvest physiology, transport and storage of fresh fruits and vegetables in U.S.A., Dr. Pratt compared and contrasted conditions in U.S.A. and Australia.

A notable similarity was that of climate in California and Australia which probably explains the frequent interchange of workers in this particular field. However the climatic conditions and geography of the remainder of U.S.A. result in a contrast in the nature of the storage problem. The main problem in U.S.A. is one of short term "moving storage" over the 3,000 miles from California to the markets in the Eastern States where a severe winter climate prevents production of fresh fruit and vegetables over a greater portion of the year.

Australia has no such major problem of transporting long distances by rail or road, and, except in connection with our export trade, "moving storage" work is in its infancy here. However in other aspects of storage and transport, Australia now shares the lead with U.S.A. and U.K., said Dr. Pratt. To illustrate some of the problems encountered Dr. Pratt explained how, in addition to refrigeration of rail cars during part of the journey, it was sometimes necessary to heat the cars while passing over high mountains. A further contrast was to be found in the organisation of the research activities; in U.S.A. the research work being mainly the responsibility of the Universities.

Outlining the general principles underlying storage and transport work, Dr. Pratt pointed out that since we are dealing with living tissues, changes after harvest are inevitable; in some cases for the good (e.g., ripening of pears, avocados, etc.) and sometimes deleterious such as wilting, decay and production of "off flavours." In augmenting the advantageous changes and controlling the deleterious changes, the three main factors to be considered and controlled are temperature, humidity and composition of the atmosphere.

Dealing first with temperature, Dr. Pratt correlated the normal growing conditions with post-harvest treatment. Cool-season crops such as peas, broccoli, etc., should be rapidly cooled to freezing or near freezing temperatures, while warm season crops, such as tomatoes and most tropical fruits, were subject to chilling injury if stored below 45-55°F. and were normally stored at higher temperatures than cool season crops. Sweet Corn and Sweet Potatoes were two of the few exceptions to this rule. Control of humidity was necessary with some, particularly leafy, vegetables to control wilting and loss of weight, or decay. Gas-storage, or control of the composition of the atmosphere, was not used much in U.S.A. but was receiving much emphasis in Australia. To illustrate these general principles, some excellent slides showing the practical application of research to the problems were screened.

Of special interest was the use of ethylene gas in ripening the Honey Dew melon, and the way in which onions, although storing well at temperatures of 30-40°F. and also at 90-100°F., did not store at all well at the intermediate temperatures of 60-70°F. Tomato fruits grown in field conditions of more than 100 hours per week below 60°C. were shown to be subject to rapid breakdown in transport and it was necessary to apply this index to discontinue marketing as conditions became progressively cooler in the autumn. The need to store lettuce at near freezing temperatures was also illustrated.

Recent Developments in Cereal Breeding.

Professor Watson.

Speaking on the subject of wheat-rust, Professor Watson reviewed the situation in Australia, dealt with the variability of the organism and concluded by discussing how these facts influenced the approach of the Plant Breeder to the problem. By the use of slides, Professor Watson showed how new strains of the organism had arisen and destroyed hitherto resistant varities and mapped the strains and wheat varieties present in Australia.

Variability within the organism could be explained by mutation; by passage through the alternate host and by nuclear exchange. Since the Common Barberry is not a contributing factor in Australia and since strains have arisen here, the Barberry Eradication Campaign in U.S.A. may not achieve the results expected. Several approaches to this problem are being adopted by Plant Breeders. One approach is to broaden the genetic basis where possible but not to hold up new varieties merely because of the possibility of introducing new specific strains of the pathogen. Another approach is to introduce resistance by intergeneric crosses with other grasses. As an example of another approach, Professor Watson cited the work of the Rockefeller Foundation in Mexico with multi-line varieties. The aim of this work is to develop several strains of the one variety and by mixing these at sowing, to have a crop which is not 100 per cent. susceptible to a particular strain of the pathogen.

The Recruitment and Training of Agricultural Scientists in Victoria.

At a symposium held by the Victorian Branch of the Australian Institute of Agricultural Science in 1955 on "The Scientific Development of Victorian Agriculture", a resolution was adopted in the following terms—

> "That this Branch organise a further symposium on the recruitment and training of scientific personnel for the development and promotion of agriculture in Victoria."

Accordingly, the Branch arranged a further symposum which was held at Burnley Gardens on 23rd March, 1956, the theme being "The Recruitment and Training of Agricultural Scientists in Victoria".

The programme was arranged in five sessions —Recruitment, Pre-University Training, Undergraduate Training, Post-Graduate University Training, and a final Review Session.

In each of the first four sessions, a number of papers were presented and discussed. Summaries of these sessions were made available for use at the Review Session.

1. *Recruitment*:

The following papers were presented in this session:—

1. "Studentships—open and tied; the source of under-graduates and the fate of scholarship holders", by Mr. B. F. McKeon, Department of Agriculture.
2. "The Education Department's policy of recruitment of secondary teachers with special regard to teachers of Science and Agricultural Science", by Mr. H. G. Henry, Education Department.
3. "Public relations in relation to teachers, parents and students, Mr. R. R. Pennefather, Convenor, Branch Sub-Committee on Public Relations.

In the first paper which summarised much factual information on scholarships available, it was shown that between 60 and 75 per cent. of agricultural science students at present received some form of financial assistance during their university course. Analysis of available records also indicated that a slightly higher proportion of these assisted students than of the non-assisted students complete their courses. The majority of students undertaking the degree course in Agricultural Science are from the metropolitan area.

The paper dealing with the Education Department's policy on recruitment illustrated methods by which recruitment is stimulated in the teaching profession. Each year the Education Department awards 800 bursaries to children after they have completed their Intermediate year, and another 400 to other students when they have gained their school Leaving Certificate, providing they agree to undergo teacher training after leaving school. In addition at least 350 studentships are awarded each year for training secondary teachers—the studentships cover all fees and a living allowance of £350-£400 per year and involve a three year bond with the Education Department.

In the third paper, Mr. Pennefather indicated that there was a real need for greater publicity as a means of stimulating recruitment for the course in agricultural science. For instance, during 1955, the demand for graduates was at least 50 per cent more than the University output. Initially, this publicity should be directed to school children during and after their Intermediate Certificate year because, at this stage of their schooling, they are beginning to give serious thought to their future careers.

The Institute's campaign to inform the public about agricultural science has involved, so far, conventional methods such as distribution of brochures, radio talks, press articles, posters, contact with teachers, and in some cases, with parents. A recent survey amongst first year agricultural science students of the factors influencing them in their choice of a career, indicated that the Institute's information campaign in Victoria had been very worthwhile.

In the ensuing discussion, several members expressed the view that the Institute should not undertake a recruiting campaign unless recruits could be assured of a continuous demand for their services and that their conditions of employment, including salary, were satisfactory.

It was the responsibility of present members of the profession to ensure that high standards were maintained and the prestige of the profession raised to a level which would attract the right type of graduate. It was also felt that caution should be exercised in the methods used in publicising the profession of agricultural science and that it would be most undesirable to exaggerate in any way the status of the profession. The keynote of any appeal for increased numbers of agricultural science students must continue to be the satisfaction afforded students in a career dealing primarily with biological science and closely bound up with rural life.

2. *Pre-university training*:

In this session, papers were presented expressing viewpoints on the following aspects of pre-university training:—

1. "Pre-university training—why?" by Mr. G. H. Vasey, University of Melbourne.
2. "Provision of preparatory courses in State secondary schools," by Mr. P. J. Wolfe, Education Department.
3. "The training of students in Agriculture, matriculation subjects with particular reference to Biology", by Professor J. S. Turner, University of Melbourne.
4. "A pre-university year", by Professor Sir Samuel Wadham, University of Melbourne.

If more students are to be attracted to the profession of agricultural science, then their interest should be aroused in the biological sciences before they have completed their Intermediate year. Steps which might be taken to stimulate this interest could be the teaching of more biology in the Intermediate and lower grades, organising field clubs and natural history societies at schools, and possibly the running of vacation camps at field stations of the Department of Agriculture.

It was suggested that the capacity of students to do a university course could generally be assessed between the ages of 11-15 years. Nevertheless, based on their good performance over a limited range of subjects, students capable of, and perhaps even interested in biological subjects, are often advised to pursue a university course in pure science or perhaps engineering because of their ability to get high marks in chemistry, physics and mathematics. Because of the relatively lower standard at which biology and agricultural science are taught in many schools, there is a tendency for poor pupils to be diverted to them, resulting in poor matriculation results in these subjects. If such students proceed to agricultural science at the university then their chances of success are not good.

It was suggested that biology should be more widely taught in schools, preferably to matriculation level; but for students who intend doing a university course it should not be taken at the expense of matriculation Physics, Chemistry or one Mathematics. Matriculation agricultural science appears to be of no value as a pre-university subject, though its importance to students who do not intend to seek a university training was appreciated.

There was a real need to encourage more country students to undertake agricultural science at the university. This could be assisted by the provision of more bursaries or scholarships at country schools continuing through the university course. However, this would not necessarily make any difference to the quality of the students coming forward for university training.

The possibility of introducing a pre-university year at post-matriculation level, with examinations supervised by the university merited serious consideration. It would reduce crowding at the university and ensure that students are more mature when entering the university. It would not, however, reduce crowding in schools and would tend to throw a greater burden on the teaching staff.

3. *University Undergraduate Training*:

The foregoing consideration of pre-university training, led naturally to a review of the university course for the degree of Bachelor of Agricultural Science.

Papers presented in this session were:—

"The Present Basic Course at Melbourne—its objective and scope." Professor Sir Samuel Wadham, University of Melbourne.

"Views on the subject matter, length of the course, and requirements for practical work." Mr. F. M. Read (Dept. of Agriculture), Dr. I. F. Phipps, (I.C.I.A.N.Z.) and Dr. H. C. Forster (C.S.I.R.O.).

"Specialisation in major fields during the B.Agr.Sc. Course." Professor Sir Samuel Wadham.

Members agreed that the present course achieved its objective of providing a broad basic training in agricultural science. As a result, a graduate was prepared adequately for more specialised post-graduate training in the career which he entered.

Whether this was research, field experimentation or extension work in a government department, research institute or in private industry, or as a primary producer, a graduand was equipped with a balanced outlook and a sound basis for handling the problems with which he was likely to be faced.

Despite this general acceptance of the course's value in providing such a broad basic training, some members felt that there should be more opportunity for specialisation in the final two years of the course.

The main objection to this was that the course was already too full to allow enough time for supplementary reading apart from what was necessarily associated with the lectures.

It was pointed out also that considerable specialisation at the undergraduate level, brought the danger of weakening the course in its admitted function of training reasonably well educated agricultural scientists.

However, it was suggested that if the course were to be re-organised to allow some specialisation, some adjustment of the curriculum might be possible during the second year in which students obtained some training in practical work in addition to the more formal studies.

An important suggestion was that closer university contact during this year of the course, would help students to settle down better to the intensive studies of the third year after their absence from the campus. At present, many students found reorientation difficult after being away from the university for a year.

Two alternatives to the year at Dookie Agricultural College were suggested, viz:—a pre-university practical year, and practical training at an institution nearer Melbourne during which closer contact than at present, would be maintained with the university.

However, there were many administrative difficulties associated with the organisation of a pre-university practical year, and it was considered that the practical training should be done at an educational establishment. Sound, practical knowledge of farm operations was important, even for students who would become research workers.

4. *Post Graduate University Training*:

Agreement that the undergraduate course gave a broad basic training without much opportunity for specialisation, paved the way for a more detailed discussion on post-graduate university training.

Papers presented in this session were:—

"The present course and facilities available in Melbourne for M.Agr.Sc., Ph.D., D.Agr.Sc. degrees." Associate Professor G. W. Leeper, University of Melbourne.

"Views on post-graduate university training." Mr. S. Fish (Dept. of Agriculture), Dr. I. F. Phipps (I.C.I.A.N.Z.) and Mr. A. J. Vasey (C.S.I.R.O.).

"Conditions needed to enable post-graduate work to be undertaken." Dr. C. R. Millikan, Dept. of Agriculture.

The need for specialised post-graduate training for almost every field of employment in the profession was recognised. This could be obtained either in formal studies, organised in-service training by an employer, or as an integral part of the junior officer's work. Formal post-graduate training for research work at a university or research institute where projects were closely supervised, often led to a higher degree.

It was felt that the financing of post-graduate training could be a big problem, especially when the trainee did not have assistance from an employer. More adequately paid scholarships plus part-time employment, such as demonstrating at a university, could relieve this position.

Another problem was the employment bonds under which many students were placed when they accepted a scholarship. It was felt that, as it was not always possible for those who awarded scholarships to be sure at the time whether an applicant would eventually prove suitable for the purpose for which the award was made, e.g., research or extension work, there could be a disadvantage in holding a graduand to a bond in a position for which he was not as well fitted as for some other field of work. Moreover, students, especially those in the early years of the course, were often not initially certain of the ultimate position for which they would be suited best by desire and training.

This situation could prevent potential research workers from undergoing post-graduate training in this field, and could channel them, at least temporarily, into other phases of employment such as extension work or teaching.

While it was accepted that entering into a bond involved certain moral obligations on the part of students, it was considered that it would be an advantage if more flexible procedure could be adopted to meet special circumstances of this kind.

Members agreed that, while post-graduate training in many fields of research could be done at universities and research institutes, there were, on the other hand, inadequate facilities in Australia for post-graduate training in other phases of research and in extension work.

Until these were available, many graduates had to rely on overseas universities for such training. Unfortunately, some people were handicapped because it was not practicable for them to travel for this purpose.

To meet this situation, it was suggested that certain Australian universities might specialise in special phases of the biological and agricultural sciences and provide facilities for students who wish to get the required post-graduate training in these particular fields.

There was a strong feeling among extension workers that more facilities should be available for post-graduate training in their field.

Opinions varied on the conditions of employment in relation to study leave, and whether higher degrees merited special consideration from employers.

Summary.

Although no formal resolutions were adopted at the symposium, the principal points emerging from the papers and the subsequent discussion were as follows:—

1. There was a need for recruitment to strengthen the profession numerically to meet the demands of prospective employers for qualified agricultural scientists.

2. At the same time, it was suggested by some members that it would be wrong to lead young people to believe that the profession offered generous and attractive salaries, working conditions and opportunities of advancement as befitted a vocation of its status.

3. As the present B.Agr.Sc. course was constituted, the best pre-university studies should include matriculation Physics, Chemistry, Biology, and one of the mathematics. The subject of Agricultural Science, while considered a valuable subject for those not proceeding to the university course, was not regarded as preferable to the above subjects at matriculation level.

4. While the B.Agr.Sc. course was valuable in providing a broad basic training, some specialisation in the third and fourth years was desirable. This is recognised to be very difficult in view of the present full syllabus, but some modification of the second year, in which practical studies were undertaken, might be possible.

5. In view of the need for post-graduate studies in nearly all fields of the profession, better facilities and opportunities for such work, were desirable.

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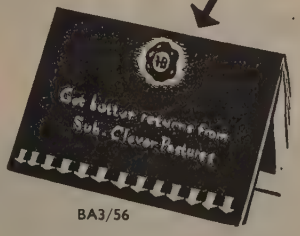

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NEWS ITEMS

Conference on Arid Zone Climatology.

A conference of wide agricultural interest was held in Canberra in October—the UNESCO Conference on Arid Zone Climatology, with special reference to Micro-climatology.

Almost half of the sixty or so members of the conference were brought from overseas by UNESCO. They included some of the world's most distinguished workers in the field, with representatives from every continent.

The sessions covered the following topics: (1) Evaporation and the Water Balance; (2) Radiation and the Thermal Balance; (3) Climatic Elements and Flora; (4) Climatic Elements and Fauna; (5) Microclimate of Man and Domestic Animals; (6) Modification of Microclimate; (7) Rain-borne Salts; (8) Instruments and Observational Requirements.

The main theme of the conference was microclimate—or the condition of the layer of air near the ground. The study of this surface air has developed in recent years as a new approach to climatic analysis. Microclimatology in this conference was taken to mean two things. Firstly, it means looking at the detailed physical happenings — radiation balance, transport of moist air in the vertical plane — which are summed up in the empirical formulae which agriculturists use in their attempts to find homoclimes. Secondly, it can mean the effect of animals or crops or trees on the temperature, humidity, and windiness of the air around them. For example, the Canberra foresters produced surprising figures for the decreased travel of wind since the settlement and planting of trees around the city.

One immediate difficulty over a conference on arid-zone microclimatology is that the subject as yet hardly exists. The world's work on microclimatology has been done in well-watered regions; one thinks of Rothamsted, Munich, New Jersey, and Melbourne's bayside. Eventually the principles and instruments that are being devised in such centres will be applied at first hand to the arid regions. Meanwhile, there are few regions, even in the well favoured parts of the world, where periodic droughts, even of only a few weeks at a time, are not such a problem as to stimulate the study of aridity.

The conference gave an opportunity for the specialists in crops and animals to meet the physicists who deal with the fundamentals of their science. Thus a dual purpose is served; the fundamental scientist learns the nature of the agriculturist's problems, while the agriculturist becomes more aware of dead-end roads or pitfalls, as well as of promising lines of enquiry. It was clear that much more of this contact is needed. Dr. Geiger's comment was much appreciated, that we do well by attaching a meteorological physicist directly to the field agricultural station.

Among the agricultural topics were the use of water on the dry side of the wilting point; light intensity and plant growth; heat limiting the growth of temperate crops; environments of desert animals; heat tolerance of cattle; and the measurement of dew. The homoclime and the pursuit of simple climatic indices were given little attention.

The 35 Australian contributions, as well as those from overseas, achieved a high level, and when the collected papers are printed, the book will be an invaluable one for the shelves of the agricultural scientist, both for the fundamental theory and for the experimental record.

The conference itself ran exactly to time-table over three days and a half, or 19 hours of active meetings. The purpose was to discuss the papers, which had already been circulated to all the members. So the papers were taken as read, and after a fifteen-minute introduction of each session by the reviewer, authors were given five minutes to call attention to salient points in their papers. The participants kept admirably to the rule, and the maximum use was made of the time. Since diagrams and tables had been included in the circulated papers, lantern slides were dispensed with.

Two interpreters worked in shifts throughout the conference. English and French were the official languages; whichever of the two was being spoken at the tables, the other was coming from the interpreter's microphone, and could be followed through the earphones that were attached to each table. The interval between the speaker's and the interpreter's words was two seconds—a feat of skill so well performed as to appear easy.

The overseas visitors, together with eight Australians, were taken on a "Study Tour" after the Symposium. They visited Broken Hill, to see both the native desert vegetation and the developing "green belts" around the town; and went on to Mildura, including the Commonwealth Research Station at Merbein. It was a very wet year for visitors to see the arid parts of the continent, but the visitors were well aware of its peculiarity and were not misled. At the end of the tour, in Melbourne, there was an excursion to C.S.I.R.O. Division of Meteorological Physics at Aspendale.

Both the conference and the tour ran very smoothly, and the organizing for this international occasion reflects great credit on the staff of C.S.I.R.O. who were responsible.

Sir Ian Clunies Ross receives Award of Gold Medal of Royal Agricultural Society of England.

Sir Ian Clunies Ross, C.M.G., D.V.Sc., Chairman of CSIRO, has been awarded the Gold Medal of the Royal Agricultural Society of England.

The Gold Medal was inaugurated in 1933 when the Society resolved: "To strike a gold medal of original design to be awarded, at intervals of one year or longer, for distinguished services to agriculture either in practice or in

science". The award carries with it Honorary Membership of the Society.

This was the first award to an Australian.

A record of the award will be kept in the Society's *Gold Medallist Book*. This volume is bound in red leather with gold edgings and contains a full page photograph of each recipient with personal details on the opposite page inscribed in Old English manuscript lettering.

Sir Ian considers the award as a recognition of the high regard in which the agricultural research of CSIRO and other Australian scientists is regarded. He pointed to the great benefits to Australia resulting from CSIRO's work on myxomatosis, the correction of trace element deficiencies as a major factor in restoring soil fertility, the overcoming of many diseases and pests of sheep and cattle, to mention only a few of the outstanding achievements in this field.

Sir Ian has done a great deal himself to reduce the time lag between research discoveries and their practical application. He has made CSIRO's work known far and wide and has successfully campaigned for improved facilities for the training of agricultural scientists.

Plant Introduction Conference

A three day meeting between representatives of the Plant Industry Division, CSIRO, the N.S.W. Department of Agriculture and the Soil Conservation Service was held in Canberra last year to review the present position of plant introduction work with special reference to pasture plants in N.S.W. and to discuss proposals for a closer future collaboration between the three bodies. *Dr. Frankel* opened the meeting at which the Department was represented by Messrs. *C. K. Vears* and *W. T. Atkinson*, the Conservation Service by Messrs. *R. Powles* and *D. G. Cameron* and this Division by Messrs. *W. Hartley* and *C. A. Neal-Smith*. *Dr. F. Morley* and Messrs. *H. Daday*, *W. Andrew* and *J. Peak* also attended for parts of the proceedings.

Recognising the need for closer co-operation the meeting assessed the requirements and aims of each body and went on to consider how each could assist the others. Obvious requirements were for better lines of communication and for better utilisation of regional testing facilities. The group has made a number of specific recommendations to achieve this better liaison. Apart from several recommendations dealing with responsibilities of each body to keep the others informed of specific types of action those of particular interest cover arrangements to use uniform system of note taking and further similar meetings at Canberra or selected regional centres such as Armidale and Wagga.

The meeting also spent some time in discussing the present state of knowledge on a range of introductions which had been listed as promising in various parts of the State by Mr. Hartley on a tour in October, 1954. A number of other specific minor problems were also considered.

CSIRO Tobacco Investigations

A new phase in the Division of Plant Industry tobacco investigations is now under way as the Tobacco Research Institute commences its activities at Mareeba, Queensland. The Institute which is being jointly financed by growers, manufacturers and the Commonwealth will eventually concern itself with all tobacco problems. Its first interest and that which will obviously dominate for many years is to raise the quality of cured leaf. This will involve the improvement of both the plant and the curing processes.

A property has been purchased some three miles out of Mareeba on the Tinaroo Creek. Of its 125 acres approximately 70 to 80 acres are suitable for tobacco growing and of these 44 are cleared and have been used for tobacco growing. Normal farm buildings on the property are of a comparatively high standard and a house is available for stationing an officer on the property. Housing arrangements for research staff have not been finalised but they will probably live in the township of Mareeba.

Laboratory buildings are being completed on the station.

Dr. D. W. Goodall, formerly Professor of Agricultural Botany at the University of Reading, has been appointed Director of the Institute. After a few days in Adelaide, Melbourne and Canberra he proceeded to Mareeba, to commence his task of familiarising himself with tobacco growing in Australia and in particular in Queensland. He will be joined later by Mr. Lovett who has been stationed at the Waite Research Institute following the closing down of activities at Ayr. A plant breeder has been appointed and joined the Genetics Section in Canberra in the New Year for about six months before proceeding North.

S.A. Prize in the Faculty of Agricultural Science.

An offer by the S.A. Branch of the Institute to provide a prize in the Faculty of Agricultural Science has been accepted by the University of Adelaide.

The Rules made by the Adelaide University Council are:—

> "Whereas the Council has accepted the offer of the South Australian Branch of the Australian Institute of Agricultural Science to provide annually a Prize of £10 in Agricultural Science, it is hereby provided that:—
>
> > A Prize, to be known as the Australian Institute of Agricultural Science (S.A. Branch) Prize, will be available annually for award to the candidate who, on completing the course for the Ordinary degree of Bachelor of Agricultural Science, shall in the opinion of the Faculty of Agricultural Science be the most distinguished of the students completing the course in that year; but no award shall be made unless the Faculty is satisfied that the candidate is of sufficient merit."

News from Western Australia.

Buildings.

The increasing importance of scientific agricultural services in Western Australia has been fully demonstrated over the past few years by the rapid expansion in research and office accommodation now built or being erected. Just over twelve months ago the new laboratories of the Institute of Agriculture and the C.S.I.R.O. were opened and recent reports indicate that the new buildings of the Department of Agriculture will be ready in the near future.

New Appointment.

The growing realization of the importance of economic studies relating to agriculture was recently emphasised by the appointment of a Reader in Agricultural Economics at the University of W.A. The appointee, Dr. H. Shapper of the W.A. Institute of Agriculture, has carried out numerous economic surveys of West Australian agricultural industries, and his intimate knowledge of local conditions will be of great assistance to students of Agricultural Economics.

The term of the appointment is initially for a period of five years, with the financial backing being made available by the Commonwealth Bank of Australia.

Poultry Science Course.

The first post-graduate course in poultry science to be held in Australia, commenced in Melbourne on 21st January and will continue until 23rd March. Twelve representatives from the six states are attending together with an Indian visitor under the Colombo plan.

The opening session was held at the University of Melbourne and the main part of the course is being held at the State Research Farm, Werribee.

The course covers all phases of poultry science and economics and is recognised by the University of Melbourne to the extent that the University Extension Committee will issue a certificate of attendance to those who complete the course.

Lectures are being supplied by the C.S.I.R.O., University of Melbourne, Egg and Egg Pulp Marketing Board of Victoria, Turkey Producers' Federation of New South Wales, the Victorian and New South Wales Departments of Agriculture and the Bureau of Agricultural Economics of the Department of Primary Industry.

SI-RO-Mark Branding Fluid.

A recent C.S.I.R.O. report indicates that in the two years since the release of the formula, SI-RO-Mark branding fluid has been used to brand most of the sheep in Australia.

In the first season more than 130,000 gallons of the fluid was sold in Australia. Twenty-six Australian firms now have C.S.I.R.O. approval to make and market the product.

SI-RO-Mark was developed to overcome the "tar" problem which was associated with the use of earlier branding fluids.

Some minor difficulties in field use have occurred, but these have been overcome, largely by ensuring that the correct method of application is adopted.

Department of Agriculture Scholarships in Victoria

The Victorian Government awarded a number of scholarships this year for students commencing university courses in agricultural science and veterinary science.

Five scholarships, each valued at over £1,000 were awarded to students who on graduation will join the district agricultural advisory service of the Department of Agriculture.

Also a number of scholarships were made available to students wishing to undertake the degree course at Massey Agricultural College in New Zealand. This course covers specialised training in dairy science and on graduation the holders will join the Dairying division of the Victorian Department of Agriculture.

In addition a number of Veterinary scholarships were made available to enable students to complete the veterinary science course at Sydney or Brisbane Universities.

Additions to McMaster Laboratory.

The Governor of New South Wales, Sir John Northcott, officially opened a new £57,000 extension to the C.S.I.R.O. McMaster Animal Health Laboratory in Sydney on 15th November, 1956.

The new wing is named after Captain Ian McMaster, son of the late Sir Frederick McMaster, one of Australia's foremost sheep stud breeders. Captain McMaster died of wounds in the Middle East in World War II.

The opening coincided with the 25th anniversary of the McMaster Laboratory. Sir John and the Chairman of the C.S.I.R.O., Sir Ian Clunies Ross, praised the work of Sir Frederick McMaster. Sir John said Sir Frederick was one of the great Australians who had helped to improve sheep breeding in Australia.

The Ian McMaster wing will house most of the Division's administrative offices and two new laboratories. The laboratories will be used for research on parasitic and infectious diseases of sheep and nutritional and other problems of the sheep and wool industry.

Australian Plant Pathologist Helps the Philippines.

Dr. C. J. Magee, Chief Biologist in the N.S.W. Department of Agriculture returned in December from Manila where he had been, for a period of two months, advising and assisting the Philippines Government in the control of Abaca Mosaic. This visit was arranged by the Technical Assistance Board of the United Nations Food & Agriculture Organization, Dr. Magee being considered the best authority available on this type of virus disease because of his work on virus diseases of bananas.

Abaca (*Musa textilis*) is the plant from which Manila hemp is obtained and production by the Philippines is almost a world monopoly. The mosaic disease of hemp has been very destructive in the last ten years and has prevented Manila hemp regaining its pre-war importance.

Dr. Magee reported that he could not support the former diagnosis of the disease being caused

by strains of cucumber mosaic virus and considered that the virus was one of the sugarcane-grass mosaic group. The disease should rightly be considered a disease of grass weeds that under certain conditions spreads to abaca. Primary infection and latent primary infection have rendered difficult the development of disease-free planting stock. It is fortunate that methods adapted from potato virus control techniques can be used for deriving disease-free planting stock and that grass can be smothered by use of leguminous cover crops. The cover crop with most promise for this purpose is *Pueraria javanica*.

As a result of Dr. Magee's investigations on the spot practical control of this serious disease of Manila hemp is likely to be achieved.

Farm Machinery.

More than 25,000 people attended the annual machinery field day at Orange, New South Wales, in November, 1956, organized by the Orange branch of the Graziers' Association of N.S.W. This farm machinery demonstration is one of the largest in the country and the record attendance at the 1956 field day showed that farm mechanization is now being widely appreciated and much better understood.

As usual many new types of machinery were on display and most were made in Australia. A new type of power-take-off operated cultivator was demonstrated which cuts 4-inch square sods and lays them back in position and has a variable working depth of 3 to 12 inches. Other new machines which also aroused great interest were several makes of scythe bar-type mowers and green feed forage harvesters.

New Snail Bait.

Recent tests by the Department of Agriculture of N.S.W. have shown a new solid snail bait to be very effective. It is durable and can be re-used many times or left out permanently in the shelter of small pots or tins laid on their sides. This new bait was suggested to the Department by Mr. K. S. Chan, an entomologist from Borneo who recently visited Australia on a Colombo Plan fellowship.

The ingredients of the bait are metaldehyde powder 1 part, rice bran (or poultry mash) 3 parts, hydrated lime 1 part and cement 3 parts by weight. The components are mixed dry after which the mixture is brought to a thick, creamy consistency with water. It is then set in a shallow pan and broken into small blocks, 2 in. x 2 in. x ¾ in., for use.

Visiting Scientists.

The number of visitors at all centres has been somewhat greater than usual due to the influx of persons on their way through to the Grasslands Congress in New Zealand. The following passed through going to New Zealand: *Mr. J. Van Rensburg*, Mpwapwa Research Station, Tanganyika, *Mr. K. Addison*, Henderson Research Station, Southern Rhodesia, *Mr. A. B. Rains*, Department of Agriculture, Northern Nigeria, *Dr. J. R. Pelletier*, Director of the Federal Research Station at St. Anne de la Pocatiere, Quebec and *Dr. J. P. Botha*, Chief of the Division of Crops and Pastures of the Department of Agriculture, Union of South Africa. All were, of course, most interested in agronomy, ecology and plant introduction and people working in these fields were kept extremely busy.

Other visitors from overseas included: *Dr. G. Burton*, Principal Geneticist, Tifton, Georgia, who spent a short time in Brisbane and Canberra. At the former centre he gave a general staff talk in addition to meeting individual officers. *Mr. G. S. Cripps* of the Climax Molybdenum Company, U.S.A. spent a couple of days in discussion with members of the Canberra nutrition section. His company is considerably involved in trace element work and this is the second occasion on which he has visited Australia. *Dr. R. Holroyd*, a member of the board of directors of I.C.I. in the U.K., made a short visit to the Canberra laboratories as portion of a tour of Australian research centres. He was accompanied by senior members of ICIANZ research staff, who joined him in discussions with Dr. Frankel.

At the invitation of CSIRO *Dr. Thacka*, Director of the Council for Scientific and Industrial Research in India has been visiting Australia to study the organisation of research in Australia. During his travels in this country he has been accompanied by *Mr. E. J. Drake* of Head Office. Dr. Thacka, besides attending the UNESCO Arid Zone Symposium during his visit to Canberra, spent some time in discussion with Dr. Frankel.

Dr. McMeakin, Director of the Ruakura Animal Research Station, New Zealand visited Australia in September. He judged beef cattle classes at the Royal Melbourne Show. Among other places, he spent some time at C.S.I.R.O. in Canberra.

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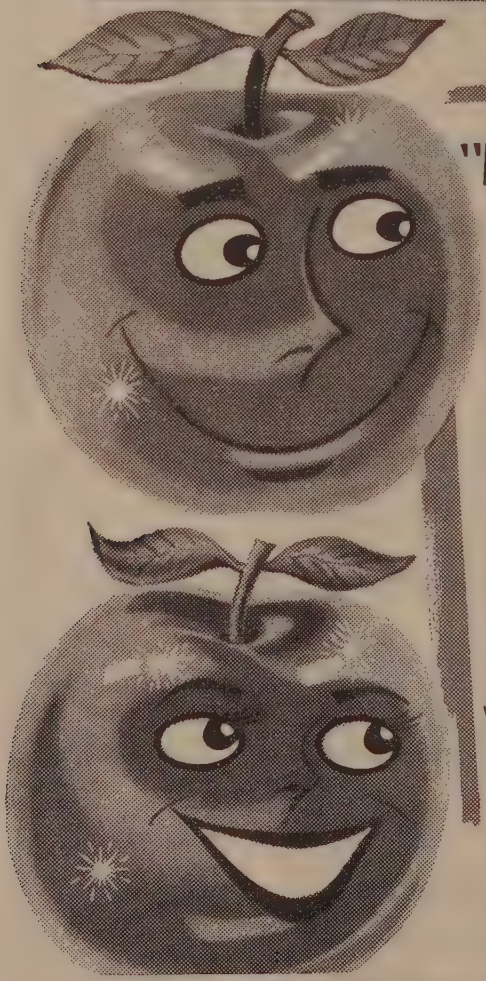

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FEDERAL PRESIDENT — 1957

Dr. W. A. T. SUMMERVILLE

Dr. W. A. T. Summerville, Assistant Under-Secretary, Department of Agriculture and Stock, Queensland has been elected Federal President of the Australian Institute of Agricultural Science for 1957. The appointment was announced by the retiring President, Dr. T. E. Edwards at the Annual General Meeting of the Institute held in Sydney on 14th March.

Dr. Summerville joined the Department of Agriculture and Stock as a cadet in 1922 and graduated B.Sc. at Queensland University in 1929.

His early research work was in the field of entomology where he made major contributions in the control of insect pests of fruit and vegetable crops.

Subsequently he became interested in plant physiology with particular reference to Horticulture, and made important contributions to the knowledge of banana culture.

Dr. Summerville's later work has been in an administrative capacity while he was Director of Horticulture and later Director of the Division of Plant Industry.

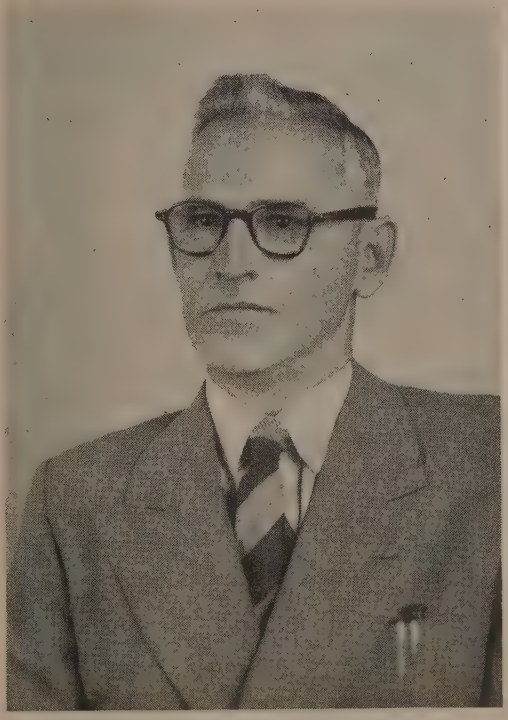
In these positions he was responsible for the development of an effective Horticultural research and extension group within the Department, a comprehensive pasture research programme and the establishment of a number of experiment stations throughout the state for research in the fields of Horticulture, tobacco and pastures.

Dr. Summerville serves on many State and Federal Agricultural Committees and has made frequent attendances at meetings of the Australian Agricultural Council and Standing Committee.

He is actively associated with the University of Queensland, being a member of the Senate, and also of sub-committees dealing with facilities for Agricultural Science research.

Dr. Summerville is a foundation member of the Australian Institute of Agricultural Science and was President of the Queensland Branch in 1943.

He brings to the position of Federal President a wealth of experience in Australian Agriculture and a broad interest in national and civic affairs.



Dr. W. A. T. Summerville

PERSONAL NOTES

Professor Sir Samuel Wadham, Dean of the Faculty of Agricultural Science at Melbourne University retired at the end of February.

Sir Samuel's long and fruitful association with Australian Agriculture commenced in 1926 when he came from Cambridge to Melbourne to take up the position of Professor of Agriculture. The Faculty at this stage had been given a fresh start by the University, with a new building of its own, and Sir Samuel was the first Professor under this new arrangement.

Sir Samuel's interest in agriculture has always been wide and his knowledge has frequently been called upon by governments in the preparation of reports on the agricultural industry. Two of his biggest undertakings outside the University were when he was a member of the Royal Commission of enquiry into the wheat, bread and flour industries in 1934 and of the Rural Reconstruction Commission in 1943-6.

Within the School of Agriculture Sir Samuel has developed a four year course of agricultural training designed to provide graduates with a broad outlook on agriculture generally and a basic knowledge which fits them for a wide variety of agricultural pursuits.

The graduate research work of the school is strong and has to a large extent specialised in surveys of land use.

Sir Samuel has always been a trusted friend of farmers and his popularity throughout the farming community is evidence enough of his practical approach to farming, both as a business and a way of life. In 1948-9 Sir Samuel was President of the Chamber of Agriculture of Victoria.

Sir Samuel was awarded the Farrer Memorial Medal (N.S.W.) in 1947, the first Australian Medal of Agricultural Science in 1948 and received his Knighthood in 1956.

He has been a member of the State Committee of CSIRO since 1944 and from 1944 until 1955 was a member of the Advisory Council of CSIRO.

He was Federal President of the Institute of Agricultural Science in 1937-38 and President of the Victorian Branch in 1943.

At an official farewell held at the Melbourne University on 7th. December last, some 450 graduates and associates of Sir Samuel gathered to wish him au revoir.

Professor Sir Samuel Wadham

The Vice-Chancellor, Sir George Paton, took the chair and introduced the three speakers. Mr. Neville Haughton spoke on behalf of graduates, Mr. W. S. Kelly on behalf of the farming community and industry, and Mr. P. Ryan, on behalf of the Department of Agriculture.

Associate Professor Leeper, as chairman of the organising committee then presented Sir Samuel with a specially bound copy of a limited edition of a book prepared for the occasion entitled *"Sir Samuel Wadham—Selected addresses with a biographical study by Geoffrey Blainey."* A substantial cheque was also presented.

Professor Leeper then unveiled a portrait of Sir Samuel by Mr. Carrington Smith and presented it to him. The portrait, subsequently handed to the Vice Chancellor by Sir Samuel, takes its place in the University gallery.

Sir Samuel in reply paid tribute to his many associates who over the years had assisted and encouraged him in his work.

Australian Capital Territory.

Mr. C. S. Christian was Australian Delegate to the Fifth Session of the International Rice Commission at Calcutta from 12th-19th November.

Mr. W. Hartley returned from Europe in October.

Mr. J. C. Turner and *Mr. J. L. Frith*, members of the Climatology unit of the Division of Land Research and Regional Survey have recently moved to Alice Springs to commence intense microenvironmental water balance studies of arid zone plant communities. It is anticipated that they will be at Alice Springs for most of 1957.

Mr. R. A. Perry of the Division of Land Research and Regional Survey attended the 7th International Grassland Congress in Palmerston North, New Zealand in November, 1956.

Mr. R. Oram, from the University of Adelaide, has joined the Genetics Section in Canberra. He will concentrate on the breeding of pasture plants firstly at Canberra, but this work is likely to involve him in a transfer to another centre at a later date.

Messrs. *A. J. Anderson*, *W. Hartley*, *E. J. Hilder*, *A. W. Humphries* and *R. M. Moore*, attended the International Grasslands Congress in New Zealand during November last.

Mr. R. Johanson has transferred to the Division of Forests Products in Melbourne.

Mr. John Possingham attended the British atomic tests at Maralinga. He had interrupted his studentship studies to return to Australia for these tests where he was concerned with radio-active fall-out effects. His main concern was with absolute counts on vegetation in the affected area, the persistence of radio-activity under various environmental conditions and the possibility of absorption of radio-active material into plant tissue through the leaf surface. It seems that conditions at Maralinga, while not providing the facilities of a capital city, were tenable enough. The main drawback appeared to be the boredom of waiting about while conditions were unfavourable for the tests.

New South Wales.

Dr. J. H. B. Christian has been awarded the degree of Ph.D. from the University of Cambridge for his work on the physiology of halophilic bacteria. Dr. Christian has recently returned to C.S.I.R.O. Division of Food Preservation from Cambridge where he worked with Dr. M. Ingram at the Low Temperature Research Station while on a C.S.I.R.O. studentship.

Two recent graduates *Mr. D. Evans* and *Mr. D. McDonald* have been appointed as Agronomists in the N.S.W. Dept. of Agriculture. Mr. Evans will be assisting Mr. I. McLean in pasture investigations at the Temora Experiment Farm, whilst Mr. McDonald will be stationed at Leeton Experiment Farm conducting research on aspects of irrigated pastures.

Dr. P. G. Valder recently returned from England where he was awarded the degree of Ph.D. from Cambridge University for his studies of the biology of *Helicobasidium purpureum*, under the supervision of Dr. S. D. Garrett. Dr. Valder returned to his former position of Plant Pathologist with the N.S.W. Dept. of Agriculture.

Mr. Harold Jenkins has recently taken up his appointment as Senior Lecturer in Agriculture at the Waite Institute.

Dr. J. P. Quirk has been appointed as Reader in Agricultural Chemistry at Adelaide University.

Dr. K. O. Donovan recently returned from Scotland where she obtained a Ph.D. from Edinburgh College of Agriculture for her work on the bacteriology of milk.

Mr. Richard Date has commenced his duties as Research Assistant, Microbiology, at the School of Agriculture, Sydney University. He will investigate, establish and maintain suitable strains of Rhizobia for the important legumes and at given periods supply mother cultures of these organisms to the commercial manufacturers. Mr. Date is acting as a member of a Laboratory Service established to act as an advisory body by agreement between the University and the N.S.W. Department of Agriculture.

Professor K. O. Campbell has been appointed Research Professor in Agricultural Economics at Sydney University.

Dr. B. Z. Breyer, Associate Professor of Agricultural Chemistry at the University of Sydney left in February on twelve months sabbatical leave abroad. A comprehensive lecture and study tour will be made through the United Kingdom, several European countries and Canada, of special interest is a course of lectures to be given at the University of Padua on A.C. polarography on which Dr. Breyer is a world authority.

Dr. Breyer will also be studying the organization of agricultural chemistry schools overseas.

The Minister for Agriculture in New South Wales recently announced two senior appointments in his Department. *Mr. A. Pearson* has been appointed Chief, Experiment Farms and Stations; and *Mr. J. L. Green* has been appointed Executive Officer, Regional Extension Services.

Retirement of Mr. E. H. Zeck.

The well-known entomologist, *Mr. E. H. Zeck*, retired from the N.S.W. Department of Agriculture in October, 1956, after 33 years of service in the Entomology Branch. Mr. Zeck is famed throughout the entomological world for his knowledge of Australian insects and for his beautiful and accurate drawings of a large number of them. He is a Fellow of the Royal Zoological Society, President of the Naturalists' Society of N.S.W. and a foundation member of the Australian Institute of Agricultural Science. Mr. Zeck was the author of "Insect Notes" in the Agricultural Gazette of N.S.W. for more than 20 years and for many years has been a teacher of entomology at the Sydney Technical College. He has given distinguished service to entomology in Australia.

Queensland.

On 31st December, 1956, *Mr. Robert Veitch* retired from the position of Assistant Under Secretary (Technical), Department of Agriculture and Stock. *Dr. W. A. T. Summerville* has

been appointed in succession to Mr. Veitch. Consequential vacancies within the Department were filled as follows:—

Mr. W. G. Wells—Director, Division of Plant Industry.

Mr. W. J. Cartmill—Director of Regional Experiment Stations.

Mr. J. E. Ladewig—Chief Soil Conservationist.

Mr. R. F. Isbell of the Bureau of Investigation recently returned from a tour of southern New South Wales and northern Victoria where he studied the use and behaviour of the soils in the irrigation areas. Previously Mr. Isbell was away from Brisbane for several weeks on a field trip which included visits to the Dawson Valley and the brigalow country along the Mackenzie River as far as the Isaacs junction.

Mr. H. K. Lewcock, formerly Pathologist with the Department of Agriculture and Stock, recently holidayed in Brisbane. In the nine years he has been in South Africa as technical adviser with Henry Jones and Co. (South Africa) Ltd. he has assisted to establish the South African pineapple industry on a sound basis. Mr. Lewcock considers the Australian pineapple industry will soon be facing strong competition from Malaya, where powerful interests are aiming to recapture the United Kingdom market which Malaya held before the war.

Obituary.

Vale "Trot"

(*Mr. E. C. Tommerup*)

With the premature death of *Eric Christian Tommerup* in October, 1956, the Institute has lost another link with its not too lengthy past. Eric Tommerup (or Trot as he has been universally known to his friends from student days) would have been very well known to all Queensland Branch members except possibly to recent importations from other States or recent graduates in other than Agricultural Science. He also had many friends and associates in other Australian States and overseas.

Trot had in his 51 years lived an extremely varied life and covered a vast field, both physically and figuratively. But then Trot was no ordinary human being—as any who have had contact with him over the last 30 years will readily testify. His career reads briefly as follows:—

1922-26—University of Queensland where he took his B.Sc. degree; entered Forestry Department.

1927—Post-graduate course in Forestry; became Associate of Australian Chemical Institute.

1929-30—Resigned from Forestry Department, and was granted a travelling scholarship by C.S.I.R. to proceed to Rothamsted and study soil bio-chemistry under Russell, Crowther *et al.*

1931-34—Was recommended by Sir John Russell to the Dunlop Rubber Company as Soils Officer for their plantation in Malaya. While in Malaya in 1932 was made Fellow of the Royal Statistical and Royal Economic Societies; in 1933 gained his M.Sc. (Q.) for a thesis covering ecological studies in South-East Queensland.

1934-35—Returned to Australia and was temporarily Soils Adviser to Lever's Pacific Plantations, carrying out some investigations on coconut fall in the Solomon Islands.

1935-38—Became Chief Research Chemist to the Eveready Battery Co., Sydney, where he directed research into special problems of dry battery manufacture.

1938—Was appointed Soil Bacteriologist with the Queensland Department of Agriculture and Stock and stationed at Atherton. Here he investigated fertility problems on the Atherton Tableland and directed a general agronomic programme. During the later war years, he was directed to special duties at Home Hill and later at South Johnstone.

1944—Was seconded to the Queensland Agricultural College at Lawes as Agriculturist; appointed Lecturer in Agronomy in 1947, and later became Senior Lecturer in Plant Industry which position he held until his retirement through illness at the beginning of 1956.

Trot was well known throughout his career for his enthusiasm, his unorthodoxy and his love for argument. At home he has been known almost to wreck one of his wife's bridge parties by slipping imperceptibly (but none the less definitely) from the contemplation of no-trumps to that of the nitrogen cycle. In his passion for argument he would take on all-comers in any environment, but his argument was almost always sustained with geniality and a sense of humour.

During his period of work at the College, he actively influenced the thinking and outlook of a decade of students in Agricultural Science. This is undoubtedly his greatest achievement for Queensland agriculture. While his direct contacts with the Institute were few, his was undoubtedly the driving force behind the annual submission of papers for the Branch Prize, which is a treasured institution of the Queensland Branch.

Many of us who knew him in earlier years often wondered since how he could possibly confine himself to the fairly rigid requirements of teaching a University course. Apparently he didn't! However, on one occasion a few years back a group of recent graduates were heard discussing their course and their lectures with great frankness. On being asked who of all their lecturers they considered had interested and influenced them most, they said without dissent, "Trot." When doubt was expressed as to Trot's capacity to stick to any single topic for an hour on end, the reply was somewhat as follows:—"Yes, we know he would commence a lecture on 'Wheat in Queensland' and finish up in the jungles of Malaya or growing cotton on the Nile, *but* during the course of that lecture he would have given us two or three things to think about, and sufficient inspiration to actually set us thinking. Other lecturers may have given us far more orderly courses, but they didn't inspire us to think for ourselves as Trot did."

I think we may safely let these graduates have the last word.

(*L. G. Miles.*)

South Australia

During the past few months, there have been numerous changes in the staff of the Waite Institute, in Adelaide.

Mr. W. R. F. Crawford has been attached to the staff under the Wool Industry funds to study

pasture insects. He replaced *Mr. D. A. Maelzer* who has accepted a permanent position on the Waite staff.

Dr. J. P. Quirk is now reader in Soil Science in the Department of Agricultural Chemistry. Formerly he was with CSIRO's Division of Soils. He replaces *Dr. C. S. Piper*, who has joined CSIRO full time now.

Proessor R. K. Morton is the newly appointed professor of Agricultural Chemistry. He is expected in Adelaide next month (April).

From N.S.W., *Mr. H. V. Jenkins* joined the staff in January as Senior Lecturer in Agrostology in the Department of Agronomy.

Other arrivals in January were *Dr. L. Paleg*, new lecturer in Plant Physiology (from the United States) and *Mr. P. W. Miles* (from Cambridge) the new lecturer in Entomology.

In addition, applications closed in February for a plant breeder and a plant physiologist, both to work on barley research at the Waite Institute.

Mr. P. Barrow has already begun duties as Barley Agronomist with the S.A. Department of Agriculture.

Tasmania.

The foundation president of the Tasmanian Branch, *Mr. F. W. Hicks*, formerly Superintendent of Extension and Technical Services, has been appointed to the position of Secretary for Agriculture.

The degree of Doctor of Science will shortly be conferred on *Mr. G. C. Wade* by the University of Tasmania. Mr. Wade has been Chief Plant Pathologist with the Tasmanian Department of Agriculture since 1947 and has contributed much to the knowledge of a wide range of plant diseases.

Mr. J. Loveday of the Soils Section of C.S.I.R.O. is at present studying at Rothamstead on a C.S.I.R.O. studentship. Mr. Loveday left for England in the middle of last year and will be away for two years.

Mr. R. N. Farquhar has left the Tasmanian Department of Agriculture and taken up a position with the C.S.I.R.O. in Melbourne.

Tasmanian members who attended the Grasslands Conference in New Zealand in November were *Mr. G. J. Martin* and *Mr. D. Paton*, both of the Agronomy Division of the Department of Agriculture. *Mr. K. D. Nicholls* of C.S.I.R.O. attended A.N.Z.A.A.S.

Victoria.

Professor Forster took up his new duties as Professor of Agriculture at Melbourne University in March. Since 1949 Professor Forster has been Assistant Executive Officer of C.S.I.R.O.

He began his career with the Victorian Department of Agriculture in 1926. From 1935 to 1937 he worked at the Iowa State College and the University of Ames, U.S.A., receiving his degree of Doctor of Philosophy in 1937. This was made possible as a result of him being awarded a Fellowship of the Commonwealth Fund of New York. This was the first time the award had been made to an Australian Agricultural Scientist.

On his return Prof. Forster was appointed Senior Cereal Research Officer of the Department of Agriculture and subsequently in 1946 he joined C.S.I.R.O. as Assistant Secretary.

Mr. W. B. Miller, Superintendent of Agriculture, spent four weeks in New Zealand during which time he attended the A.N.Z.A.A.S. conference.

Mr. J. V. Mullaly left on 12th March for Canada and the United States of America for a period of 9 months. For approximately six months he will be at the Central Experiment Farm, Ottawa, studying techniques associated with cereal experimental work.

Mr. F. Crawford recently returned from a trip to the U.S.A.

Miss I. J. Stewart returned at the end of December after a study tour of poultry science in Canada, United States and United Kingdom.

Western Australia.

Mr. A. M. Stewart, the Assistant Director of the Institute of Agriculture, Crawley, returned to Western Australia on January 28, after a year's absence on study leave. Mr. Stewart visited many European countries, notably Portugal, Spain and Italy, where climatic conditions are similar to those experienced in the South-West of the State. In addition, Mr. Stewart toured Britain and Scandinavia.

Dr. D. P. Drover returned to the Institute of Agriculture in December, after one year's study leave in Scotland. Dr. Drover carried out further research at the Macaulay Institute of Soil Research, Aberdeen, where he studied methods employing radio active iron to determine the surface or chemically active layer in Scottish soils, with a view to correlating this property with phosphate absorption.

Mr. J. Yates has been appointed to the Plant Industry Section of C.S.I.R.O. and is to be stationed in Brisbane. Mr. Yates has carried out research in plant breeding at the Institute of Agriculture over the last five years, where he was closely associated with Dr. J. Millington. Mr. Yates is to take up his new appointment in February.

The degree of Doctor of Philosophy was recently conferred upon *Dr. H. Shapper* of the University of W.A. Dr. Shapper has been engaged on agricultural economics research at the Institute of Agriculture since he came to W.A. from New Zealand some six years ago. Following this, Dr. Shapper was appointed to the newly created position of Reader in Agricultural Economics at the University, the financial assistance being supplied by the Commonwealth Bank for an initial period of five years.

Mr. J. Silsbury, a former member of this Institute, and now stationed at the Waite Institute, Adelaide, returned to W.A. recently on leave. Whilst here he married Miss Elizabeth White, also of Adelaide.

Mr. R. Slatyer and *Mr. J. Frith*, former members of this Branch and now stationed at Canberra, were in Perth recently on leave. Both are members of the C.S.I.R.O.

Mr. K. Newton has returned to W.A. after two years with the Department of Agriculture

of Papua and New Guinea. Mr. Newton was based on Port Moresby where he was engaged on soil research.

Mr. N. Godfrey, a former student member, has taken a position with the Victorian Department of Agriculture at the Werribee Research Farm.

BRANCH NOTES

Australian Capital Territory.

124th General Meeting of A.C.T. Branch of the Australian Institute of Agricultural Science, held at University House on 28th July, 1956

Present. The President, Dr. Williams, was in the chair and 65 members and visitors attended.

Minutes of the previous general meeting were read and confirmed.

The President introduced the guest speaker, Prof. James Bonner, who spoke on "A plant physiologist looks at the future."

At the conclusion of the talk a vote of thanks was given by Dr. Frankel, seconded by Mr. T. Colquhoun.

Minutes of the 125th General Meeting of the A.C.T. Branch held at University House on 4th October 1956 at 8 p.m.

Attendance. The President Dr. Williams was in the Chair and 22 members and one visitor were present. The Executive Officer was present by invitation.

Apologies were received from Mr. Hill, Mr. Strutt, Mr. Biddiscombe, Mr. Christian, Mr. Smith and Mr. Campbell.

Welcome. The President extended a welcome to Mr. van Rensberg of Tanganyika.

Minutes of Previous Meeting were taken as read and confirmed on the motion of Mr. Grogan, seconded by Mr. Lipsett.

Address. Dr. R. D. Brock addressed the meeting on "Induced mutations in plant breeding".

Discussion of Institute Affairs

The President referred to his report as Principal Delegate at the last Council Meeting which had previously been distributed to members, together with the letter to members from the Executive Officer and the copy of the "Plan Ahead".

Dr. Williams pointed out that several important issues had been discussed at the recent Council Meeting to which members should direct their attention. Some of the more important policy issues which he had in mind were:—

(i) the decision to maintain the Central Secretariat beyond the trial period due to end in September, 1957.

(ii) the decision to raise subscriptions so as to enable the Institute to maintain the Central office without outside financial assistance.

(iii) the progress being made in the raising of funds to purchase the building at 226 Clarendon Street.

(iv) raising funds from Industry, and methods of using this money to fulfil the objects of the Institute.

(v) action arising from the Branch Meeting in July when the Institute's activities relating to recruitment were discussed. The Chairman referred to the recent resolution by Council changing the emphasis in the publicity campaign towards employment opportunities and ensuring that professional qualifications were fully used by graduates. He drew attention to the proposal to seek the co-operation of the Standing Committee on Agriculture in a comprehensive review of the supply and demand position for agricultural scientists.

Motion. The following motion was proposed by Mr. Willoughby, seconded by Mr. McLennan—

That the A.C.T. Branch of the A.I.A.S. views with concern the policy of the Institute in encouraging large numbers of students into the profession without adequately warning them that:—

(i) some of the relatively few available employing authorities readily suppressed any display of initiative engendered by university training;

(ii) in many of the avenues of employment the agricultural graduate is often expected to perform long and arduous labouring duties;

(iii) future employment is nebulous, and

(iv) relative to other professions of equal training the remuneration is low.

Amendment. The following amendment was proposed by Mr. Duggan, seconded by Mr. Neal Smith.

That sub-paras (i) and (ii) be omitted and that the ideas in (iii) and (iv) be expressed in more moderate terms.

In the discussion on the amendment and motion members were unanimous on the need for the Institute to watch closely the position regarding employment opportunities and working conditions within the profession especially in the extension service. Strong differences of opinion existed, however, on the wisdom of the Institute's publicity to date regarding Agricultural science as a profession and on the terms in which the Branch views should be expressed and conveyed to Council.

The amendment was put to the meeting and was lost on the voices. The motion was then put to the meeting and carried by 12 votes to 8.

The Executive Officer, at the invitation of the Chairman then addressed the meeting.

Mr. Roberts stated that he felt that criticism of the recruitment policy was not based on facts. The original recruitment campaign was based on fact at the time it was started. Referring to the Plan Ahead, Mr. Roberts said that it was an accepted principle that we need money from

industry and the Plan Ahead was the second of two documents, the first being a rewrite of the old pamphlet pointing out what the Institute is and what it does. This second document states what we are planning to do. He considered it to be a responsible and attractive document. It has been distributed to the daily newspapers, 200 firms, the Standing Committee, people whose names are on it and all members of the Institute.

In conclusion, *Dr. Williams* stated that there had been a breakdown in communications between Council and individual members. He believed that we should improve our method of communicating with members. So long as members did not attend meetings, there was no alternative but to rely on the Branch Committee for decisions. In future, more circulars will be sent to members.

The meeting closed at 11 p.m.

Minutes of 126th General Meeting of the A.C.T. Branch held at University House on 8th November at 8 p.m.

Attendance. The President, Dr. Williams, was in the chair and 36 members and visitors were present.

Apologies were received from Mr. Christian, Mr. Colquhoun, Dr. Phillis, Mr. Stewart, Mr. Clark, Mr. Duggan and Mr. Johnstone.

Welcome. Dr. Williams extended a welcome to Mr. McIntyre of the Commonwealth Bank, who is a member of the N.S.W. Branch.

Minutes of the previous meeting had been circulated. It was moved by Dr. Brock, seconded by Mr. Campbell, that they be taken as read and confirmed. The motion was carried unanimously.

Business Arising out of Minutes

Referring to Mr. Willoughby's motion, passed at the 125th General Meeting, Dr. Williams advised the meeting that the Committee had decided to send the contents of the resolution to the Federal President and the Executive Officer, and now that the minutes had been confirmed they would be sent to other Branches for their information.

Address. The President then called upon Dr. Frankel to deliver his address entitled "Some Thoughts on Agricultural Research Abroad and in Australia".

At the conclusion of the talk the subject was open for discussion; Mr. Strutt, Mr. Willoughby and Mr. Grogan commented on Dr. Frankel's remarks. Dr. Williams then thanked Dr. Frankel on behalf of the Branch for his most interesting talk.

Institute Business

The Chairman informed the members of Mr. Ives' report on the recent Council Meeting. About £9,355 was in sight for the purchase of the Central Office Building, and members were reminded that their contributions were still required.

The main business in which members evinced interest was the discussion at Council of the use of Industry funds now in hand. The A.C.T. Branch had submitted three proposals for consideration:

1. Arrange a Conference on "The State of Food and Agriculture in Australia".
2. Pay expenses of extension workers to undertake interstate visits, preferably in groups.
3. Run a series of paid advertisements on the contributions of Agricultural Science in order to influence public opinion towards a ready acceptance of money grants by governments for further research and extension work.

Council had asked the A.C.T. Branch to work out more detailed proposals relating to the proposed Conference.

The Chairman asked members to comment on these developments, and for suggestions as to how the funds collected from Industry might be spent to fulfil the purposes of the Institute.

During discussion a number of views were put forward on the subject of raising money from Industry. Some members considered that the Institute should not under any circumstances obtain money from Industry organisations. Others took the view that there should be specific ways laid down as to how the money will be spent.

A further viewpoint was that some very useful results had already been achieved by using money donated by Industry, particularly, as pointed out by the President, in publicity relating to careers and recruitment and in publicising the value of Agricultural Science generally. The President requested new ideas as to how funds available could best be used.

New South Wales.

Recently the N.S.W. Branch Committee decided that a newsletter should be prepared regularly and sent to all members. This additional service has now been operating for a year and has been welcomed by Branch members.

Although there was no general meeting of the Branch during the November, 1956-January, 1957, period the Branch Committee has been active. The recent decision by the N.S.W. Government to curtail drastically appointments, and even replacements, to the Public Service has caused concern in the Branch. It affects employment of graduates and in the long run is prejudicial to agricultural production. The Branch Committee has expressed its concern to the N.S.W. Premier and is taking further action in the matter.

The Branch Committee has been surprised at the detached attitude of the Federal Council of the Institute to such matters as the recruitment and employment of agricultural graduates in New South Wales which the Council regarded as a "State" matter only. It feels that the relative responsibilities of Federal Council and State Branches in these matters requirees considerable discussion and clarification. Opinions have frequently been expressed that the public should be much better informed on the contributions of the agricultural graduate to the welfare of the community. The Branch considers that this is a

field in which Federal Council could take a much more active lead.

Queensland.

The 134th Ordinary General Meeting of the Branch was held at the Queensland Agricultural High School and College, Lawes, on 22nd September, 1956. The meeting was convened on the basis of a family day for members and their friends, similar to that held during 1955 at Maroochy Experiment Station, Nambour. The party, totalling over sixty in number, was welcomed by the Branch President, *Professor L. J. H. Teakle* and the Principal of the College, *Mr. N. W. Briton.* The remainder of the day was spent viewing agricultural exhibits and activities.

At the following meeting on 24th October, *Dr. J. M. Harvey,* Biochemist, Animal Research Institute, Brisbane, delivered a comprehensive address on "Trace Elements in Animal Nutrition." Dr. Harvey's own special field of research has been the role played by fluorine, particularly an excess quantity in artesian bore water, on the development of sheep.

The 136th Ordinary General Meeting, held on 28th November, 1956, was devoted to the Queensland Branch Prize which is offered annually to the undergraduate of the Faculty of Agriculture, University of Queensland, who presents the best paper to an examining sub-committee. The three student finalists for 1956 were *Messrs. J. K. Leslie, G. Diatloff* and *Miss D. E. Nunn.* The Branch adjudicators awarded the prize to *Mr. J. K. Leslie,* who also was awarded the prize in 1955. Mr. Leslie's paper was entitled "Some physical properties of soil from row and inter-row spaces of a row grass pasture."

South Australia.

A special meeting of the S.A. branch was held on December 11, following the resignation of eight members who were not in agreement with the present policy of the A.I.A.S. Council. Dr. C. Forster flew to Adelaide to represent the Federal President, who was unable to attend. Dr. Forster explained the role of the A.I.A.S. central office to members, giving details of what had been done and what the central office hoped to do in the future. Long discussion followed this talk but no resolutions were passed.

On December 14, the S.A. branch held a barbecue for 14 visiting scientists from the International Grasslands Congress. More than 60 people gathered to meet the visitors and to hear talks by Prof. W. K. Kennedy (Cornell University, U.S.), Mr. A. S. Foot (U.K.) and Dr. T. M. Stevenson (Ottawa). The barbecue was held at the Waite Institute with the co-operation of the director, Dr. J. Melville.

The S.A. branch held its annual general meeting on March 8.

Tasmania.

The Branch Annual Dinner was held in a truly agricultural (or perhaps horticultural) setting in the tearooms at the Botanical Gardens on December 14. The attendance was not as good as in previous years but those present enjoyed a very pleasant evening.

Victoria.

The Annual Garden Party to welcome new Graduates was held in the gardens of the Agriculture School at the University on 7th December. There were 115 members and friends present to partake of the refreshments, followed by an excellent repast, which was on a somewhat grander scale than usual, because of the fact that everyone was moving on to the presentation to Professor Wadham later in the evening.

The weather, always a doubtful factor when organising a garden party in Melbourne, was well up to Olympic standards and added to the pleasantry of the occasion.

The President, Mr. C. E. Cole welcomed the new graduates to the profession and presented the first book prize of the Victorian Branch of the Institute to Mr. J. B. Coombe who was dux of the final year.

At 8 p.m. a great body of graduates with their friends joined the many others who were present in Melba Hall to take part in the official farewell to Professor Sir Samuel Wadham.

Details of the presentation and speeches are presented elsewhere in this Journal. Suffice it to say here that Victorian members say farewell to Sir Samuel in his office as Professor of Agriculture with regret, but are happy to know that he will still be active in agricultural circles.

All good wishes for the coming years are extended to Sir Samuel and Lady Wadham.

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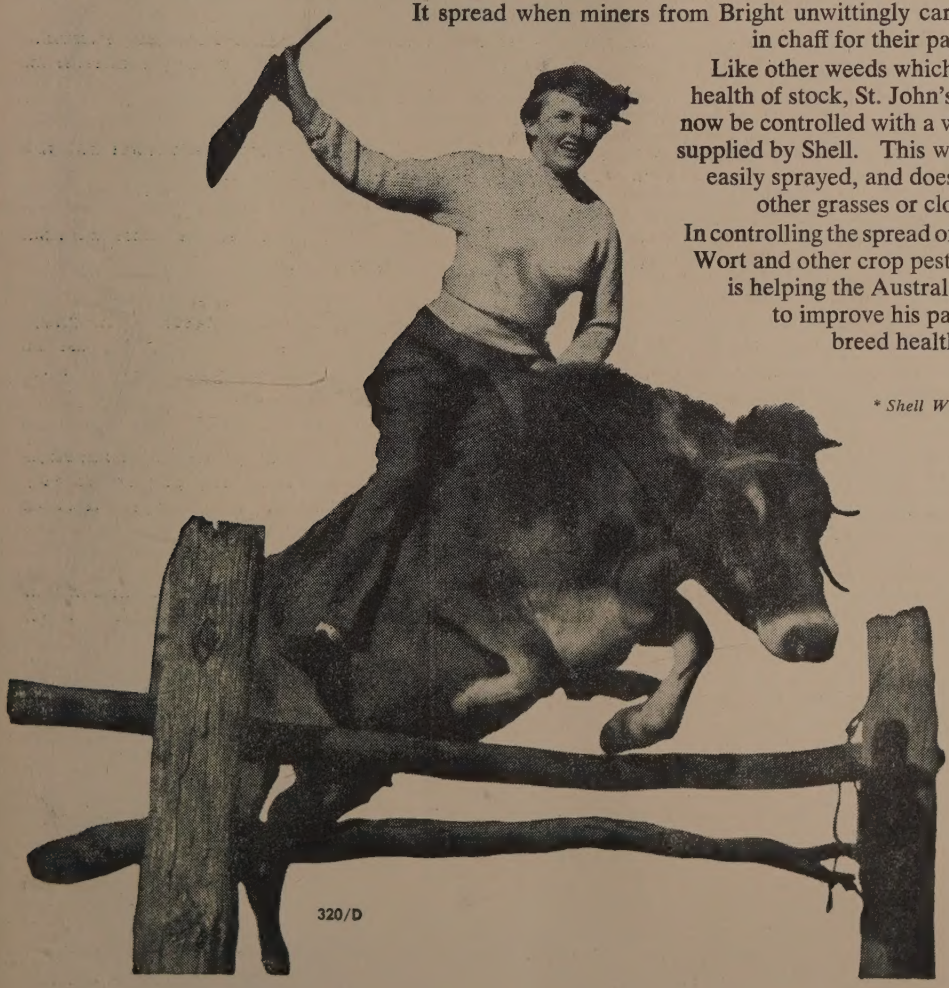

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